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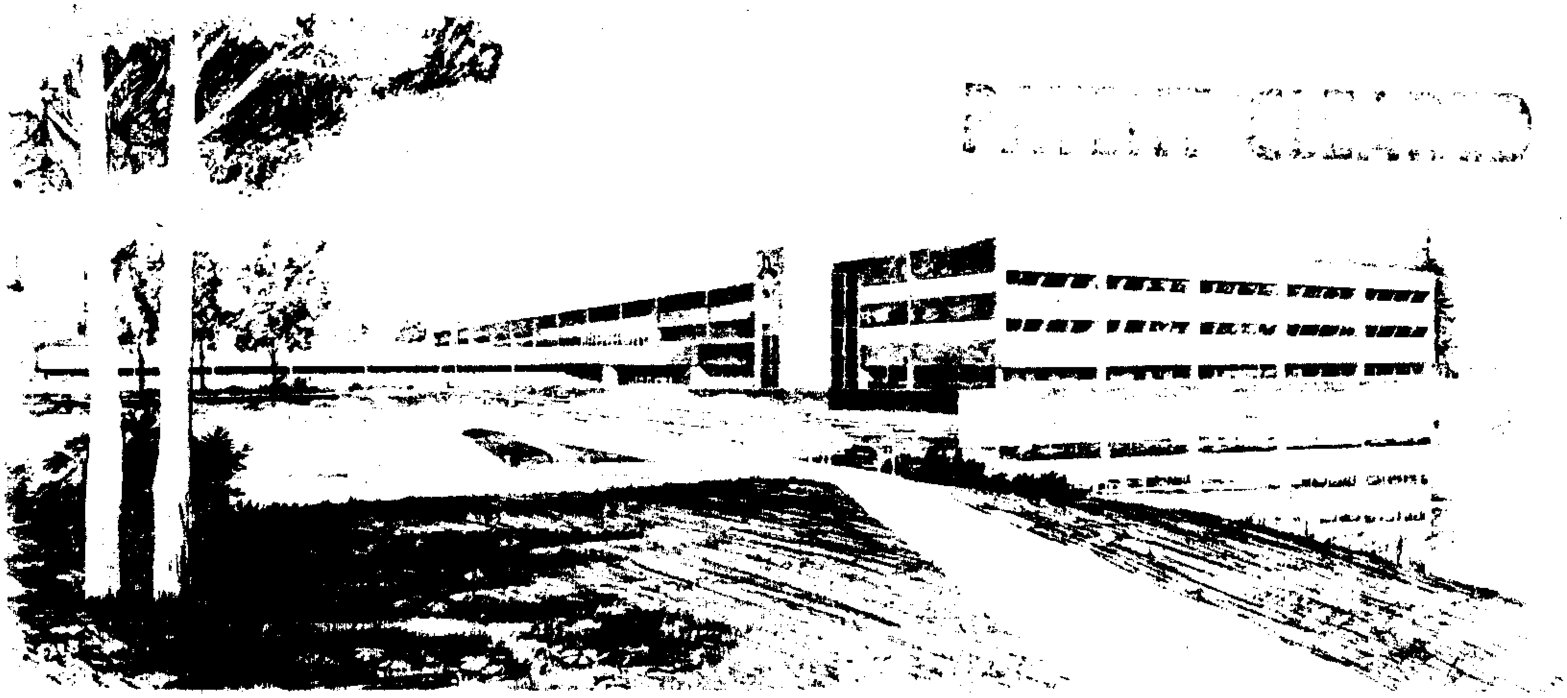

U.S. Department of Energy

Idaho Operations Office • Idaho National Engineering Laboratory

Decontamination and Decommissioning of the Organic Moderated Reactor Experiment Facility (OMRE)

Robert E. Hine

September 1980

Prepared for the
U.S. Department of Energy
Under DOE Contract No. DE-AC07-76IDO1570

EG&G Idaho

EGG-2069
Distribution Category: UC-70

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ABSTRACT

This report describes the decontamination and decommissioning (D&D) of the Organic Moderated Reactor Experiment (OMRE) facility performed from October 1977 through September 1979. This D&D project included removal of all the facilities and as much contaminated soil and rock as practical. Removal of the reactor pressure vessel was an unusually difficult problem, and an extraordinary, unexpected amount of activated rock and soil was removed. After removal of all significantly contaminated material, the site consisted of a 20-foot deep excavation surrounded by backfill material. Before this excavation was backfilled, it and the backfill material were radiologically surveyed and detailed records made of these surveys. After the excavation was backfilled and graded, the site surface was surveyed again and found to be essentially uncontaminated; the surface radiation field was at the INEL background level (less than 20 μR/hr), and isotopic analyses showed the nuclide concentrations also equal to the local background. This site was returned to the government for future unrestricted use.

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DECONTAMINATION AND DECOMMISSIONING OF THE ORGANIC MODERATED REACTOR EXPERIMENT FACILITY (OMRE)

INTRODUCTION

This report documents the decommissioning and decontamination (D&D) of the Organic Moderated Reactor Experiment (OMRE) facility at the Idaho National Engineering Laboratory (INEL) site in Idaho. This facility was located approximately 45 miles west of Idaho Falls, Idaho; its location on the INEL site is shown in Figure 1. (NOTE: All figures are presented at the end of the report, following the text.)

This project was the first of the present INEL D&D Program. The facility was selected as the first because it was deteriorated and within one mile of U.S. Highway 20. The primary goal of this project was to decontaminate the OMRE site sufficiently to return it to the Department of Energy (DOE) for unrestricted use: this was accomplished. The project was started in October 1977 and was completed in September 1979. The site presently conforms to the unrestricted use criteria specified in References 1 and 2. The surface radiation of the excavation and backfill material measures 20 μR/hr or less, and the nuclide content of the backfill soil averages less than 0.5 pCi/gm.

DESCRIPTION OF THE FACILITY

History

The Organic Moderated Reactor Experiment (OMRE) facility was designed to investigate the use of an organic coolant and was operated from 1957 to 1963. Following final reactor shutdown, the nuclear fuel and reactor vessel internals were removed, and the organic coolant was drained from all the systems. The facility remained in this deactivated condition until October 1977, when dismantling and removal of the facility was begun. Figure 2 is a photograph of the facility before extensive demolition. Figure 3 is a drawing of the facility showing the positions of the major components.

D&D of the OMRE facility presented a variety of safety-related problems. Most of the facility contained relatively low contamination levels; only the reactor vessel presented a severe radiation hazard (350 R/hr). Other hazards existed, however, in the disassembly of the facility. In addition to the normal industrial hazards, most of the facility contained a toxic and flammable organic coolant marketed under the trade name Santowax R. During reactor shutdown, xylene, which is also flammable, was used in the fuel wash system to remove this organic from the fuel before defueling. Thus, pockets of explosive xylene mixtures might have remained in the piping. Another hazard was that almost all piping was covered with asbestos, which posed an asbestosis health hazard.

Physical Description

Site Boundaries. The OMRE site boundaries are defined as follows: The southern boundary is the main access road from Jefferson Boulevard to the Experimental Organic Cooled Reactor (EOCR) facility. The site is bounded on the west by the berm separating the OMRE site from the EOCR site. The remaining boundary is described by a line drawn from a point on this berm just south of the holding pond to the intersection of the access road and Jefferson Boulevard. Figure 4 shows the OMRE site.

Physical Plant. The plant consisted of a 4,300 ft^2 steel process and control building, a large air blast heat exchanger, a storage area, an auxiliary heat exchanger, an underground reactor, a pipe gallery, several underground tanks, and extensive piping and electrical systems. Figures 5 through 10 are photographs of the facility taken from various directions. Figure 11 is a telephoto shot of the reactor area shown in Figure 2.

Radiological Description

Before starting D&D operations, the EG&G Safety Division conducted a radiological survey of the facility. The highest activity found was the core area of the reactor vessel, which exhibited a field of 350 R/hr. The removal and disposal of such a vessel producing this high field required development of special procedures and precautions; these are described beginning on page 13. Figure 12 is a radiation map of the facility made before starting dismantling. Soil samples taken around the reactor showed that the soil was contaminated, but the extent of contamination was not accurately known until reactor excavation permitted more detailed surveys. Later in the project, it was found that the soil surrounding the reactor area, the concrete base, and the underlying basalt were activated rather than merely contaminated.

DECONTAMINATION AND DECOMMISSIONING APPROACH

Objectives

The primary objective of this project was to remove the entire facility, and return the site to DOE for further use. This entailed removing and disposing of all contaminated articles, including plant hardware, soil, and some basalt rock, and salvaging all uncontaminated items. This objective was achieved. The site has been returned to a radiological state meeting the criteria for unrestricted use published in References 1 and 2.

A secondary objective was to determine what techniques, procedures, and special tools should be developed for further INEL and other D&D projects. During this project, a number of noteworthy items warranting further development were identified; these are described on page 13.

The D&D team made special effort to optimize the contaminated waste burial space utilization by packaging waste components as densely as practical. Wherever possible smaller items were nested inside larger items. All material was surveyed to segregate the contaminated from the noncontaminated. The noncontaminated, nonhazardous material that was unsalvageable was sold for scrap. Figure 13 is a photograph of this scrap material, which was sold for $2,812.

Decontamination and Decommissioning Operation

Special Project Documentation. A number of documents were developed as the project progressed. These documents make up the OMRE Project data package. These documents are listed in the References Section; memoranda pertaining to the normal and routine operations are not included.

Project Management. The INEL Waste Management Program (WMP) Division provided D&D project management. A project engineer, assigned full time to the project, was responsible for the planning, coordination, and overall direction of the project. He was also responsible for all budget, schedule, and reporting aspects. Safety and quality support were obtained from their respective divisions.

Plan Preparation. A detailed D&D plan[3] was prepared early in FY 1978. Plan development required acquiring and studying the facility records and drawings, conducting a site radiological survey, and preparing detailed cost estimates of the major facets of the job. The available records and facility drawings were of limited value since they were incomplete, and not "as built" in many cases. D&D planning also required a safety evaluation[4] for dismantling the facility.

Site Preparation. D&D of a contaminated facility requires that personnel have access to emergency showers, clothing change rooms, toilets, water, and rest facilities. Since the unoccupied EOCR facility was nearby, a portion of it was upgraded to provide these necessities plus a field office.

Cleanup. The first work phase was a general cleanup of the facility. Figures 14 and 15 show the general disarray found at the OMRE site. The loose items found were surveyed and disposed of appropriately.

Electrical Systems Removal. The first step of the demolition was the removal of the instrumentation and control electrical systems. Figures 16, 17, 18, and 19 show some of the electrical panels, wiring, and cableways in the control room. Figure 20 is a photograph of the control console. Figure 21 shows the control room after removal of the electrical equipment.

Piping Systems Removal. There were basically five separate piping systems in this facility. They were:

1. CORDOX, CO_2 fire extinguishing system
2. Main loop coolant and moderator system
3. Coolant purification loop
4. Impurities removal loop (IRL)
5. Fuel wash system.

These systems existed both inside and outside the process and control building and were interwoven in such a way as to preclude removal of one system at a time. Because these systems were being removed in the winter of 1978, the work schedule was adjusted to conform to the weather. That is, during milder days the outside piping was dismantled and during the bitter cold days, work progressed inside the process and control building.

CORDOX System—The CORDOX system piped CO_2 throughout the process and control building. The pump and gas supply were housed outside the process and control building as shown in Figure 22.

Main Loop System—The main loop system was a circulation system for the organic moderator used in the experiments. The moderator is flammable and toxic and, although the system had been drained at shutdown, there was the hazard that some residual organic might be found in the piping. The technique for handling this hazard is described on page 12. The pumps for this system were located in the process and control building and the piping connected this building with the reactor, the pipe gallery site, the heat exchangers, and the purification and impurity removal systems.

The organic material used was Santowax-R, a mixture of terphenyl and diphenyl isomers. This material is solid at 70°F, starts melting at 100°F, and is completely liquid at 200°F. Some of the main loop piping inside the process and control building is shown in Figure 23. Figures 24 and 25 are views of parts of this system located outside. The main loop pump equipment area in the process and control building before and after removal can be seen by comparing Figures 23 and 26. Before cutting these pipes, the heat tracing and asbestos was removed. Figure 27 shows this asbestos removal technique: the workers are wearing coverall clothing and respirator masks and are using a specially filtered industrial vacuum at the point of asbestos removal. Figure 28 shows a worker removing some heat tracing and demonstrates the cramped working conditions faced in removing these complex piping systems.

Coolant Purification Loop—Closely tied in with the main loop piping system was the organic coolant purification system. This system was used to remove the deteriorated organic coolant that accumulated during reactor operation. Figure 29 is a photograph of part of this system in the process and control building. Figures 30 and 31 show the purification system pit before and after system removal.

Impurities Removal Loop (IRL)—The organic coolant was circulated through the impurities removal loop (IRL) system to extract particulate impurities and maintain the quality of the coolant. Figures 32 and 33 are photographs of this system taken before the dismantling was begun. Removal of this system was started in the winter of 1978. Figure 33 is a closeup view of the outside piping. Figure 34 shows the dismantling work in progress and the difficult working conditions. Figure 35 is an overview of the conditions that existed during this part of the project.

Fuel Wash System—During the reactor operating history, the fuel was intermittently removed for programmatic purposes. When fuel was removed, it was placed in the fuel wash system to remove the organic coolant. The wash fluid in this system was xylene. Figure 36 shows the aboveground portion of this system.

Air Blast Heat Exchanger. Disassembly and removal of the air blast heat exchanger is depicted in Figures 37 and 38. The contaminated heat exchanger tube sheets were loaded onto a lowboy as shown in Figure 39 for shipment to the Radioactive Waste Management Complex (RWMC). Figure 40 shows the west side of the OMRE facility with the heat exchanger and the IRL system removed. For before and after comparisons, see Figures 11 and 40.

Process and Control Building. With the piping and electrical systems removed, the next step was to remove the process and control building. This building was removed in sections (see Figures 41 and 42), and each section was surveyed to determine the proper disposition category (i.e., radioactive waste, sanitary landfill, or surplus scrap).

Underground Tanks. After the systems described above were removed, tank excavations and concrete demoliton was started (see Figure 43). The following underground tanks existed in this facility:

- 2 xylene storage tanks—steel
- 2 septic tanks—concrete
- 1 waste water tank—steel
- 1 reactor drain tank—steel
- 1 IRL system drain tank—steel
- 1 liquid waste drain tank—steel
- 2 unknown-purpose tanks—steel (east of the fuel wash system)

- 1 gasoline storage tank—steel
- 2 organic coolant storage tanks—steel.

These tanks were excavated, measured for contamination and disposed of accordingly. Those tanks found contaminated internally only were sealed with tape and plastic at all openings and sent to the RWMC. Those found externally contaminated were completely wrapped in polyethelene plastic, taped, and sent to the RWMC. Figure 44 shows two such tanks ready for shipment. Figure 45 shows one of the two xylene storage tanks. This one was clean; the other was internally contaminated. Figure 46 shows the riggers preparing to hoist one of these tanks. Two concrete septic tanks were excavated, found uncontaminated, broken up, and buried in place. Figure 47 shows a steel waste water tank that was found to be internally contaminated. Figures 48 through 51 show a typical tank removal sequence. The reactor drain tank was found in an underground vault. Figure 52 shows this tank in place with the vault ceiling removed. The walls of the vault and the outer surface of this tank were uncontaminated.

Concrete Demolition. Those concrete parts of the facility that were uncontaminated were broken up and buried in place. The wall in Figure 53 was broken, laid flat, and buried. Figure 54 shows part of this broken wall that was pushed into the burial excavation. Figures 55 through 57 show a bulldozer preparing the excavation before breaking down the shield wall. These large pieces of concrete were measured to be less than 0.1 mR/hr and were pushed into the pit with the shield wall and buried.

Pipe Gallery. West of the reactor was a part of the coolant system referred to as the pipe gallery (see Figure 3). This consisted of a silo, a vertical corrugated steel pipe about 15 ft in diameter and 15 ft long. The reactor coolant pipes passed from the reactor to the main coolant system through this silo. There was an uncontaminated circular concrete lid on top of the silo that had to be removed in order to make a radiological survey of the inside of the silo. The corrugated silo and the external surface of the coolant pipes were uncontaminated. The soil was excavated from around the silo as shown in Figures 58 and 59. When adequately exposed, a door was cut in the side of the silo to permit workers to enter and cut and remove the contaminated coolant piping. After the piping was removed, the silo was completely excavated and removed from its concrete foundation.

Reactor Pressure Vessel and Silo. Before the reactor pressure vessel and silo were removed, soil samples were taken alongside the silo. Analyses showed that the soil samples taken at several elevations contained ^{60}Co, ^{152}Eu, and ^{154}Eu and no ^{137}Cs, an indication of soil activation rather than spill contamination. Further investigation showed that this activated soil extended about 3 ft horizontally from the reactor silo. Excavation of the soil around the silo was a straightforward task as shown in Figures 60 and 61. Details of the handling of this activated soil are given on page 13.

After the silo was excavated, a door was cut in the side to permit a welder with a lead shield wall to enter the annulus and cut the pressure vessel free. The details of removing this silo are described in Reference 5.

The reactor pressure vessel was installed to be permanent, with no provision for future dismantling. The special dismantling problem caused primarily by the high radiation field is detailed on page 13. The removal and transportation of the reactor vessel to the RWMC required the development of a detailed, operating plan.[6]

Reactor Pad. The reactor pressure vessel was mounted on a concrete slab foundation referred to as the reactor pad. This pad was a reinforced concrete structure poured directly onto a bed of basaltic lava rock. Construction drawings of this pad did not exist; Figure 62, a photograph taken during construction, was the only information available concerning the structure of this pad. After the reactor pressure vessel and its silo were removed, the excavated pit was surveyed to determine the extent of residual radiation on the reactor pad. Figure 63 is a radiation map of the pit. The reactor pad surface field varied from 15 to 50 mR/hr. The results of nuclide analyses of concrete and metal samples taken from the reactor pad surface, are shown in Table 1. These nuclide levels would not permit unrestricted release if left in place. Several techniques for removing the pad were studied, and the use of high explosives was found to be the most cost effective. This provided a unique opportunity to test the control of contamination spread while using high explosives. Several small test blasts were made to evaluate the concrete break characteristics and the throw control.

Table 1. Excavation pit sample analysis (gamma-emitting radionuclides—other than natural) (μCi/gm)

Nuclide	Stud Bolt from Reactor Casing - 150 gm	Rebar Sample from Reactor Pad - 54 gm	Concrete Sample from Reactor Pad - 345 gm
^{60}Co	1.09 ± 0.01(-2)	3.80 ± 0.04(-2)	6.1 ± 0.1(-4)
^{134}Cs	—	—	2.6 ± 0.4(-5)
^{137}Cs	—	—	<4.0(-6)
^{133}Ba	—	—	2.8 ± 0.3(-5)
^{152}Eu	—	—	2.96 ± 0.06(-3)
^{154}Eu	—	—	3.4 ± 0.2(-4)
Total gamma:	1.09 ± 0.01(-2)	3.80 ± 0.04(-2)	3.96 ± 0.06(-3)

Notes: Values are ± 1 standard deviation. Numbers in parentheses are exponents of 10.

Contamination control was effected by calculating the specific charge and placement within the concrete structure, and by placing a surface outgas and shock-wave capturing cover. The cover consisted of several layers of tarpaper and rubberized carpeting (for absorbing shock energy), a layer of 8-mil thick hypalon plastic, and chain link fence fabric (for capture and damping). Reference 7 is the detailed slab demolition plan.

To measure the effectiveness of the contamination control, the entire excavation was covered with hypalon plastic sheet (see Figure 64), several high volume air samplers were placed around the excavation, and one was hung over the pad. Plastic surface wipes were taken and analyzed before and after the blasting. The swipes and the air samplers detected no contamination spread outside the excavation. There was some rock throw, but it was successfully contained within the excavation. Figure 65 shows the concrete pad break up, and Figure 66 shows that the pad was successfully sheared from the basalt bed.

Reactor Basalt. After the removal of the reactor concrete pad, the surface radiation of the underlying basalt ranged from 3 to 10 mR/hr. Core samples of the underlying basalt were taken for nuclide analyses; these results are shown in Table 2. A shielded Geiger-Mueller (GM) tube was lowered into the core sample drill holes and the mR/hr readings decreased to about 0.1 mR/hr at about 18 inches depth. Here again, it was decided that high explosive techniques could be effectively and economically used to break up the basalt bed for easy removal. Reference 8 is the basalt breakup plan. Figure 67 shows the blaster setting charges in the pit and Figure 68 shows the results. After this rubble was removed, a detailed radiation survey of the pit was performed and a final sampling was taken for nuclide analysis. The final radiation survey data are shown in Table 3 and the nuclide content data are presented in Table 4. These levels were considered acceptable for this pit location and nothing more was removed.

Site Release. Before a site disposition can be recommended following D&D, it is necessary to survey and document, in detail, the residual contamination levels both at the surface and below ground. For this project, a detailed plan[9] was developed to survey the excavation, the backfill material, and the finished site. Before the excavation was backfilled, surface radiation measurements were made every 15 ft and selected

Table 2. Excavation pit basalt sample analysis (gamma-emitting radionuclides—other than natural) (pCi/gm)

Sample	in.	^{60}Co	^{137}Cs	^{152}Eu	^{154}Eu
Core #1	0-12	240 ± 4	—	647 ± 16	50 ± 4
Core #2	0-6	109 ± 4	—	304 ± 15	25 ± 4
	6-12	26 ± 1	—	73 ± 4	6 ± 1
	12-24	10 ± 1	—	26 ± 2	2.4 ± 0.6
Core #3	0-8	210 ± 5	—	549 ± 17	49 ± 4
	8-12	42 ± 2	—	101 ± 6	10 ± 2
	12-24	10 ± 1	0.2 ± 0.1	28 ± 2	2.5 ± 0.4

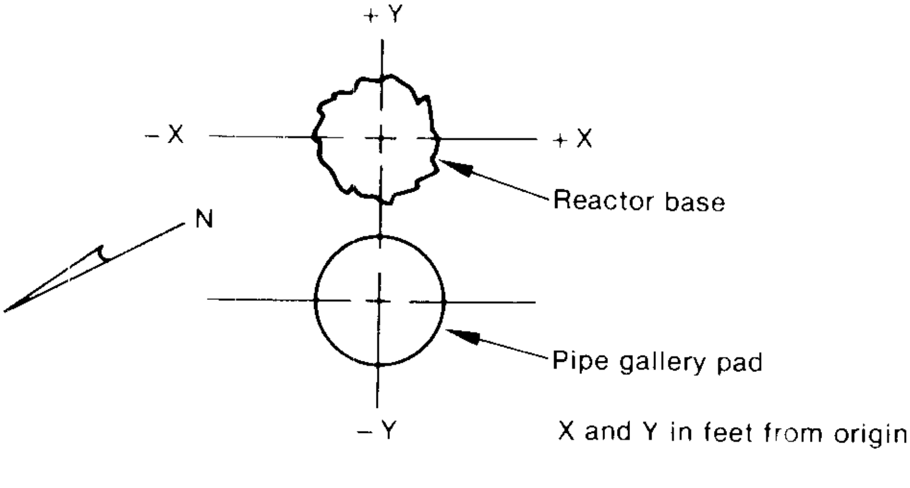
NOTE: ± variations are 1σ values.

worst-case core samples were analyzed. The concrete rubble surveyed as "clean" (less than 0.1 mR/hr at the surface) was selected as backfill, and the soil backfill was completely surveyed and sampled at 15 ft intervals. These detailed measurements are included in Reference 9. After the site was backfilled and graded, a back-and-forth, overlapping sweep of the entire area was made with a road scanner developed by the DOE Radiation and Environmental Services Laboratory (DOE-RESL), located at the INEL. This scanner consists of 24 GM tubes suspended from a 12 ft straight bar attached to the front of a four-wheel drive vehicle. Electronic readout meters and alarms were located in the cab of the vehicle. The established RESL procedure was followed in driving this scanner over the OMRE site. A standard cesium source was used to check the proper functioning of each GM tube and alarm circuit. The background radiation level was measured near the OMRE site at about 450 cpm and the detector alarms were set to go off at about 350 cpm above background. The vehicle was driven over the site in overlapping swaths at about 2 mph (idle speed in compound low). As a check of proper system functioning, the standard cesium source was intermittently laid on the ground ahead of the scanner; it was correctly detected each time. To add further confidence to the results of this survey, one contaminated spot was found and investigated. A small stainless steel chip, 1 1/4 x 2 1/8 x 1/16 in. thick, was found buried about 1 in. deep. This chip was analyzed and found to contain ^{60}Co.

In addition, DOE-RESL personnel performed a final manual surface check with a μR/hr meter. This survey was made by randomly measuring the field at different locations over the site. The fields measured were very low, averaging about 15 μR/hr. (RESL area surveys show that the buttes south of the INEL average about 25 μR/hr.) As described in the backfill plan,[9] 31 soil samples were analyzed from the area considered most likely to be contaminated, and these were compared with soil samples taken from uncontaminated locations near the OMRE and from the city of Idaho Falls. The data from all of these measurements can be found in Reference 9. Reference 10 compares the OMRE measurements and nuclide analyses.

In summary, the surface radiation measurements taken every 15 ft in the excavation were 0.1 mR/hr to 0.2 mR/hr; the concrete back-fill items all measured less than 0.1 mR/hr on the surface; and the nuclide content of the backfill soil ranged from 0.3 to 2.7 pCi/gm with an average measurement of 0.49 pCi/gm. The nuclide contents of these samples are shown in Table 5. The nuclides found were ^{137}Cs, ^{60}Co, and ^{152}Eu. These man-made nuclides, compared to the

Table 3. Excavation surface radiological survey (mR/hr)



Y (ft) \ X (ft)	-105	-90	-75	-60	-45	-30	-15	0	+15	+30	+45	+60	+75	+90	+105
+105	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
+90	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
+75	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
+60	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
+45	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
+30	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
+15	.1	.1	.1	.1	.1	.1	.1	.2	.1	.1	.1	.1	.1	.1	.1
0	.1	.1	.1	.1	.1	.1	.1	.15	.15	.1	.1	.1	.1	.1	.1
-15	.1	.1	.1	.1	.1	.1	.1	.2	.1	.1	.1	.1	.1	.1	.1
-30	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
-45	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
-60	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
-75	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
-90	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
-105	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1

Table 4. Excavation pit basalt final sample analysis (gamma-emitting radionuclides—other than natural) (pCi/gm)

Sample[a] X	Y	^{60}Co	^{137}Cs	^{152}Eu	Total
-60	0	3	<0.1	11	14.1
-60	-30	0.4	<0.1	2	2.5
-60	-60	0.2	<0.1	<0.2	<0.5
-30	0	3	<0.1	9	12.1
-30	-30	3	<0.1	14	17.1
-30	-60	4	<0.1	17	21.1
0	+30	81	<0.2	330	411.1
0	0	19	<0.1	45	64.1
0	-30	31	<0.4	140	171.4
0	-60	43	<0.1	240	283.1
+30	0	0.1	<0.1	3	3.2
+30	-30	24	<0.1	120	144.1
+30	-60	43	<0.1	180	223.1
+60	-30	3	<0.1	20	23.1
+60	-60	0.3	<0.1	2	2.4

a. The same coordinate system was used as in Table 3.

Table 5. Comparison of gamma-emitting radionuclide content from various locations (pCi/gm)

Location	Nuclide Content
OMRE backfill soil	0.5
Junction of Arthur and Jefferson Boulevards—INEL	0.9
Junction of E. Portland Avenue and Jefferson Boulevards—INEL	0.7
Dirt road, 1.5 miles NW of OMRE—INEL	0.7
L.D.S. Temple vicinity—Idaho Falls	1.2
EG&G Computer Facility—Idaho Falls	2.4
I.F. High School Playing Field—Idaho Falls	1.5
Natural (^{40}K and Th-U daughters at INEL)	63.0

naturally occurring nuclide, ^{40}K, were found to be approximately 30 times less abundant than the natural ^{40}K.

To arrive at a reasonable site release recommendation,[11] the radiation survey and sampling data were used for several exposure pathway analyses. The paths analyzed were direct radiation, wind pickup of soil, personnel intrusion into the excavation, and site flooding. These pathway analyses, although depicting the extreme worst-case, show that personnel exposure would be less than that allowed by 10 CFR 20.105 a.[12] The details of these analyses are presented in Reference 13.

WASTE VOLUMES

Uncontaminated Material

All uncontaminated material (< 0.05 mR/hr) having any salvage value was collected for surplus sale. Figure 13 is a photograph of this material in a staging area. The material was sold as scrap for $1812. Nonsalvageable, noncontaminated material (< 0.1 mR/hr) was sent to a sanitary landfill.

Contaminated Material

All contaminated material (> 0.1 mR/hr) was shipped to the Radioactive Waste Management Complex (RWMC) for disposal. Wherever possible, the contaminated material was cut or broken and placed in 4 x 4 x 8 ft plywood boxes before shipment to the RWMC. (See Figure 69.) Contaminated soil and rock was shipped in 2 x 4 x 8 or 4 x 4 x 4 ft boxes. Table 6 is a summary of the major types of waste from this project. It is important to note that the volumes listed in the contaminated column are not the volumes of these waste materials alone, but are the volumes consumed in the burial ground by these materials and their containers.

When packaging into plywood boxes was inappropriate, the contaminated articles were sealed in plastic and shipped to the RWMC as a unit, usually on a pallet. Figure 70 shows both boxed and unboxed contaminated items ready for transport to the RWMC.

Table 6. OMRE waste summary

Waste type	Clean		Contaminated
Metallic	860 ft^3		40,000 ft^3
Concrete	110 ft^3		600 ft^3
Soil	—		9,500 ft^3
		Total:	51,000 ft^3

EXPOSURE HAZARDS

Asbestos

Most of the facility piping was covered with asbestos. Removal of the piping required cutting the pipes and this, in turn, required removing some of the asbestos covering. The hazard of asbestos inhalation was avoided by requiring the workers to wear respiratory masks and by placing a high-efficiency particulate (HEPA) filtered industrial vacuum at the point of any asbestos cutting. In addition, the workers wore lapel air samplers that were periodically examined to assess the vacuum system effectiveness. These periodic examinations disclosed that there was no personnel exposure to asbestos particulates greater than 5 micro-meters in length and the particulate density was less than 2 fibers per cm^3 (OSHA[14] allowables). Figure 27 shows two workers removing asbestos insulation from a pipe before cutting.

Explosion

During reactor defueling in 1963, xylene was used as a fuel element wash after fuel removal. Thus, the possibility existed of finding some xylene trapped in the piping. The potential hazard of cutting into pipes containing explosive xylene mixtures was resolved by using a standard explosion meter to detect the presence of xylene in the pipe. If xylene were found, the pipe was to be purged with nitrogen prior to cutting. As an additional precaution, flame cutting in this system was prohibited. No explosive mixtures were detected during the pipe removal.

Toxicity

Unknown quantities of the organic moderator remained in the system piping. This material is Santowax-R, a mixture of diphenyl and terphenyl isomers; it is flammable and has minor irritant physiological effects. To minimize the fire hazard, flame cutting was prohibited on all portions of the OMRE system known to have contained this material. Cutting was done with hacksaws and pipe cutters, and fire extinguishers were stationed at the cutting site. As a precaution against skin contact, the workers wore anti-contamination clothing, including gloves and respirator masks. As it turned out, the residual organic found had the consistency of grease and the hazard of airborne particles was small. Measurements disclosed that the organic contained only low-level radioactive residue (less than 500 cpm). As the pipes containing organic material were removed, the ends were sealed with plastic sheeting, and they were placed in shipping boxes.

Radiation

This project conformed to the DOE policy of maintaining personnel radiation exposure as low as practicable (ALAP). This was accomplished by initially establishing safety plans and by following exposure control procedures during the work. Basically, these precautions consisted of establishing emergency procedures and facilities and conducting area radiation surveys before allowing workers to enter. Radiation control areas were then established and all material and personnel leaving the control area were monitored to control contamination spread. While working in a controlled area, a constant air monitor (CAM) was set up to detect and signal the occurrence of airborne activity, and anti-contamination clothing was worn by workers, as specified by the project health physicist. Dosimeters worn by all project personnel were monitored at the end of each shift. Daily, weekly, and monthly records of dosimeter readings were kept during this project. The highest exposure recorded was a single-day exposure of 0.04 rem, which was two-thirds of the daily allowable dose. Records show that the maximum individual monthly radiation exposure was 0.585 rem; ERDAM-0524[15] allows 3 rem per quarter. The total cumulative personnel exposure was 4.153 rem for the entire project.

SPECIAL PROBLEMS AND SOLUTIONS

Reactor Pressure Vessel Removal

The reactor vessel was installed with no provision for future dismantling. Figure 71 is a simplified drawing of the reactor vessel installation. This vessel could not simply be hoisted out of the pit because of the interlocking piping. Also, the anticipated radiation field in the annulus between the reactor vessel and the silo prevented manually cutting the vessel free.

The solution was to fill the reactor vessel with concrete to a depth of two or three feet above the core. With the shielding effect of this concrete, the upper portion of the silo, vessel, and sand was safely removed.

The next planned step was to fill the annulus between the vessel and the silo with concrete and then remove the entire entombed assembly: reactor core, pressure vessel, and silo. However, after removal of the upper structure, radiation measurements showed that the highest field in the annulus was 5 R/hr, and less than 100 mR/hr near the bottom. At these levels, it was possible to safely cut the silo and reactor vessel free and remove them separately from the foundation.

Contaminated Soil

Disposition of the soil around the silo was a straightforward task, but a significant discovery was made. Figure 60 shows a clamshell shovel starting this excavation and a plastic sheet on the ground to catch any droppings from the shovel. The shovel loads were slowly swung over the plastic and unloaded into wooden boxes as shown in Figure 61. This method of excavation was permissible because the soil was damp and workers were restricted to digging only on dead-calm days. At this phase of the job, the discovery was brought to light when a health physicist surveyed some soil dropped onto the plastic sheet from the clamshell and found it was clean. However, his survey over the soil deposited in the box recorded about 100 mR/hr. Surveys of other soil droppings disclosed that the soil was largely clean with isolated "hot spots." The D&D team hypothesized that this is what one would expect of irradiated soil: certain elements in the soil would be activated to long-lived radioisotopes such as ^{60}Co or ^{154}Eu. Since there was no means of soil decontamination or segregation, it was necessary to dispose of all the soil—consuming valuable burial space with clean soil—until a detailed survey indicated no more significant contamination.

Soil Spill Incident

In October 1978, a shipment of radioactive soil enroute from OMRE to RWMC sprung a leak and spilled an estimated 0.5 ft^3 of soil. An investigation of this incident was conducted by a specially appointed committee, and a report[16] was issued with recommendations aimed at preventing future such incidents. In summary, one 2 x 4 x 8 ft plywood box (about 5,500 lbs) was transported with supports under the ends only and the weight of the soil opened a bottom seam of the box. Figure 72 shows the improperly loaded box with the unsupported center and a tie-down chain aggravating the situation. Figure 73 shows one box on the verge of opening the bottom seam, and Figure 74 is a close-up view of the opened seam. Some soil was collected from the truck bed, and radiation was measured at 5,000 cpm. The personnel involved, the truck tires, and roadway were monitored and no detectable radiation was found. As a result of this incident the box design was strengthened and specific instructions regarding shipping and tie-down were emphasized.

Required Decontamination and Decommissioning Development

Since this was a first D&D project, a great deal was learned. The project demonstrated that such a nuclear facility could be dismantled and decontaminated without overexposure, using conventional demolition tools. It also demonstrated a strong need for (a) D&D research into special tool development for cost reduction and improved safety, (b) research into decontamination of soils, and (c) the development of industry-wide acceptable release criteria based on known physiological effects rather than speculation.

Considerable time and money was spent surveying the complex piping systems to differentiate the contaminated from the uncontaminated. An instrument similar to an infrared scope or camera capable of visibly disclosing radiation would have been extremely valuable in cost savings and in improving safety. Such a device is presently being investigated on a very small scale at INEL.

Contaminated soil was removed by manual and clamshell power shovels, and was placed in 2 x 4 x 8 ft boxes. This project filled about 100 such boxes with dirt and rock. A combination enclosed hopper truck and bucket-type conveyor would have eliminated the need for boxes, saved significant labor costs, and reduced the exposure hazard.

The need exists for a technique to decontaminate or segregate contaminated soil from clean soil. This project consumed valuable burial space with clean soil that was mixed with the irradiated soil. Research on soil decontamination by selective planting is in its infancy and was reported in FY-79 in Reference 17.

PROJECT COSTS

This project was initially scheduled and estimated to last two years and cost $700,000. In actuality, the project lasted two years, beginning in October 1977 and ending in September 1979, for a total cost of $500,000. The cost history of the project is shown in Figure 75.

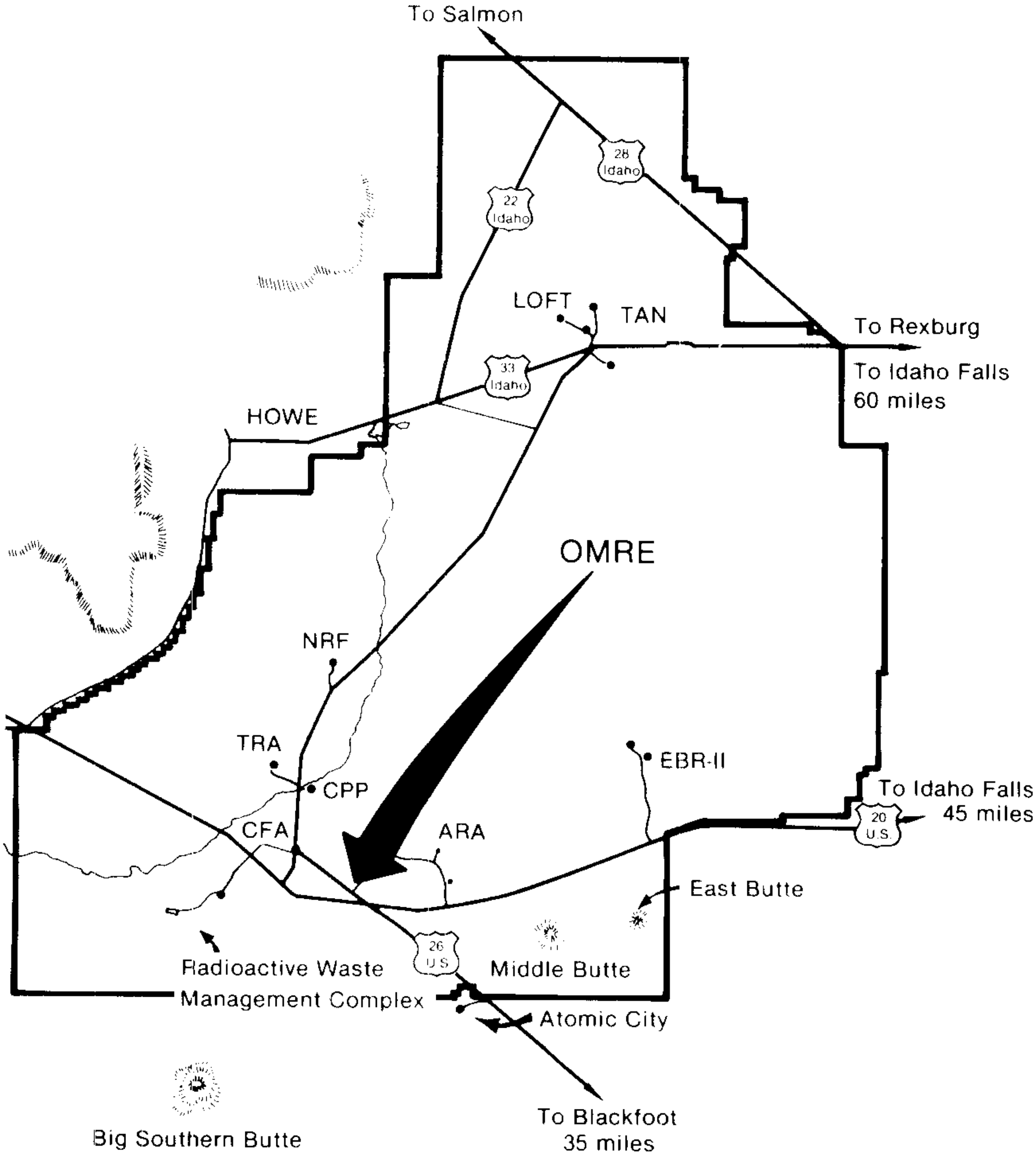


Figure 1. OMRE location at INEL.

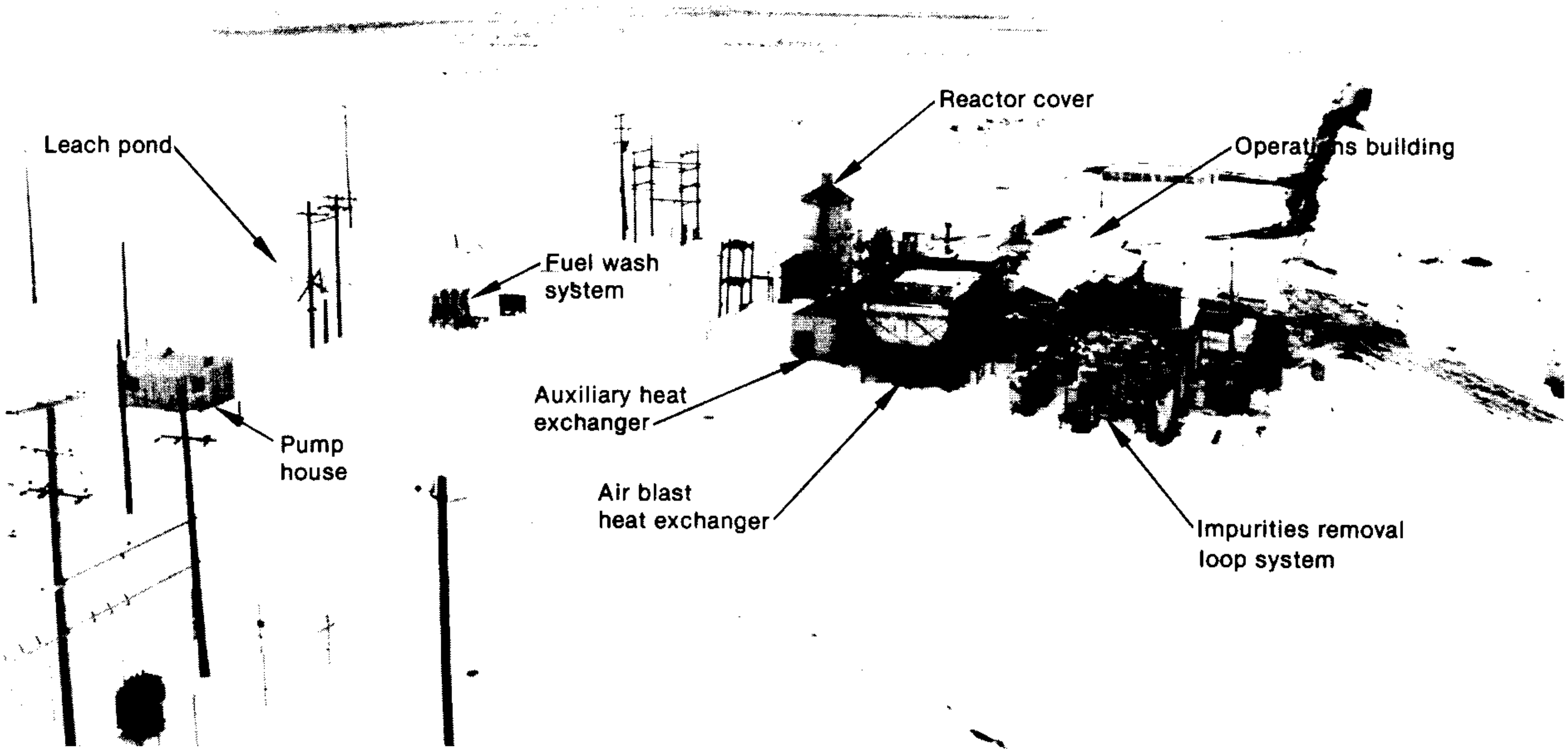


Figure 2. Aerial view of OMRE at start of D&D work.

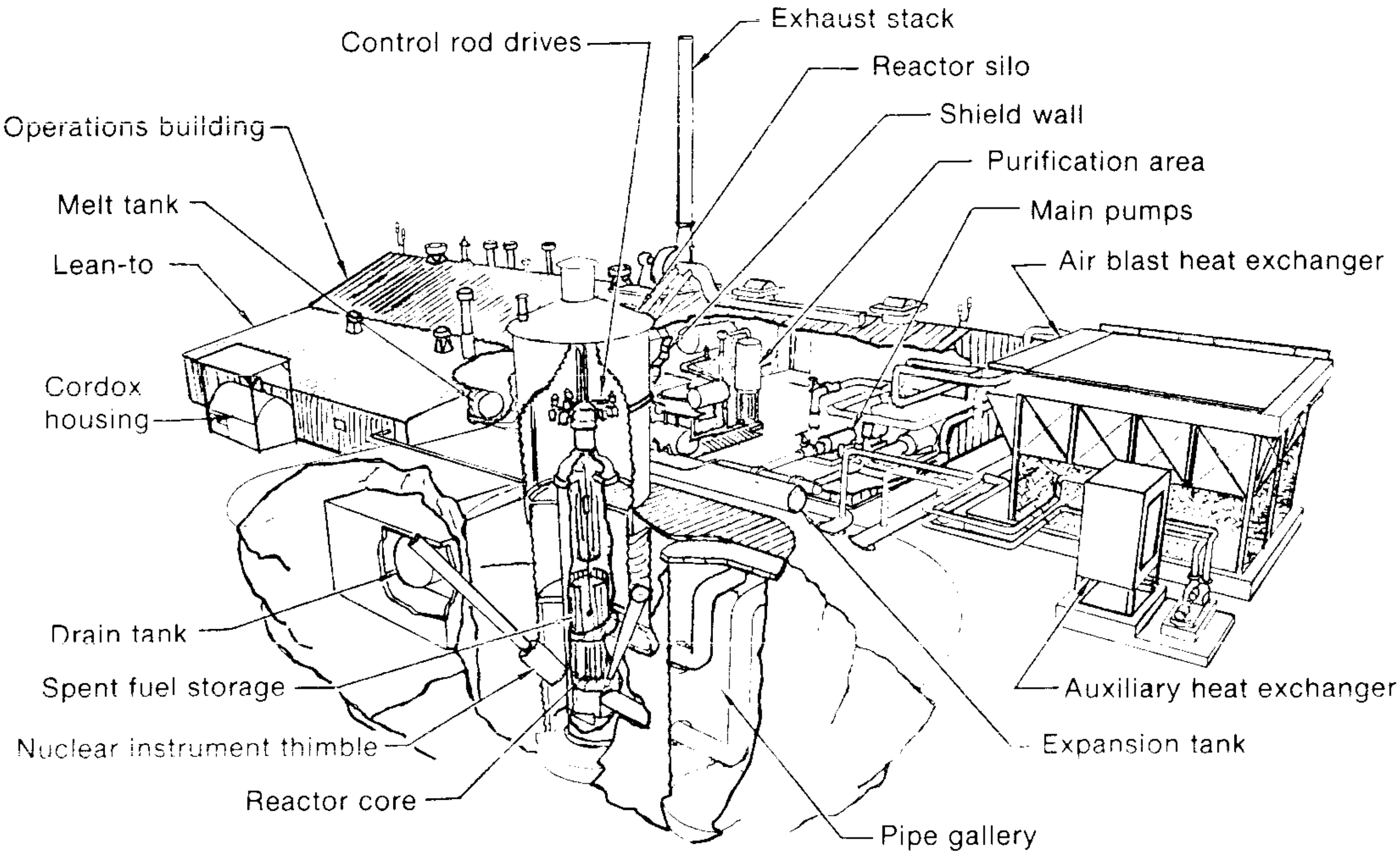


Figure 3. Perspective view of OMRE facility.

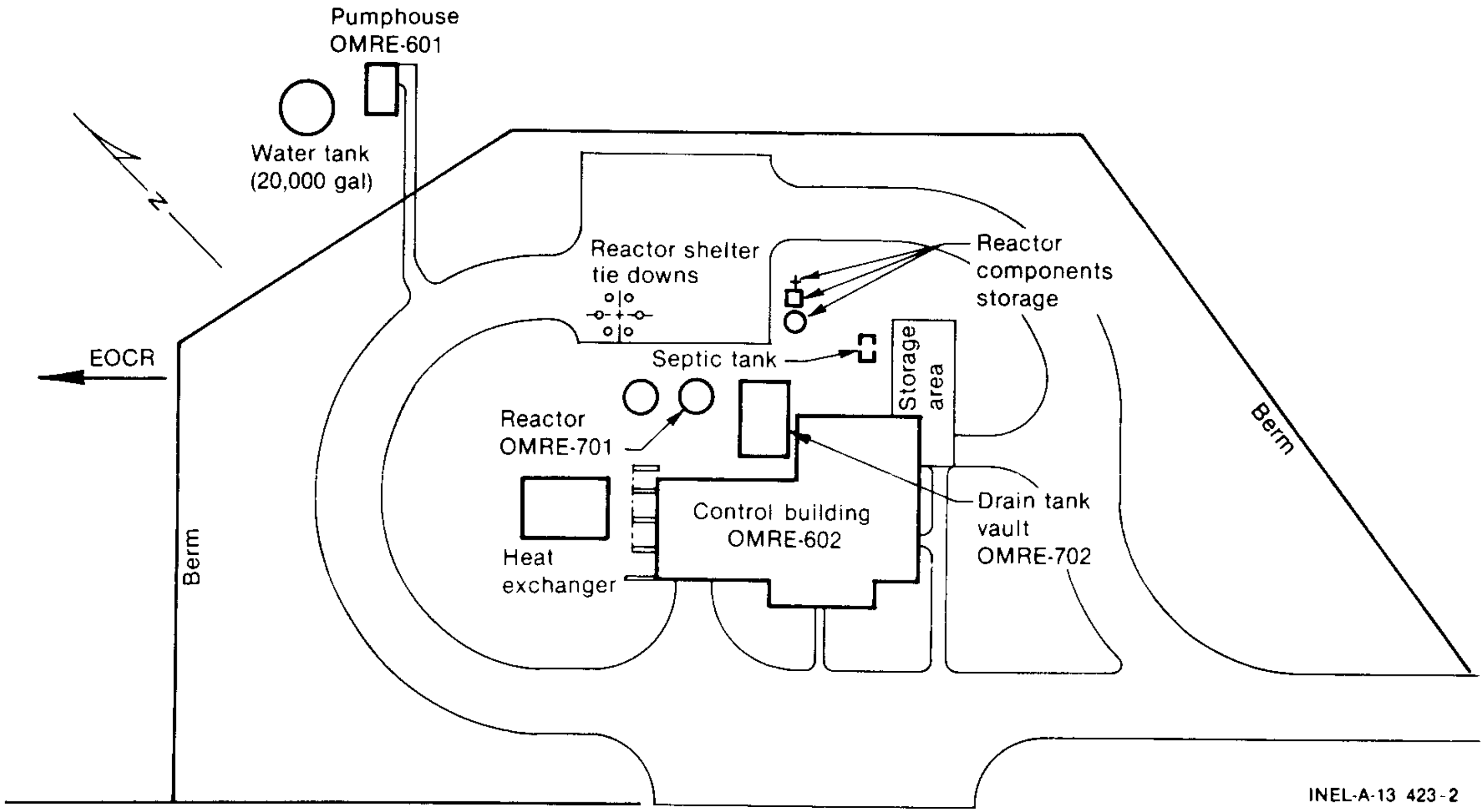


Figure 4. OMRE site boundaries.

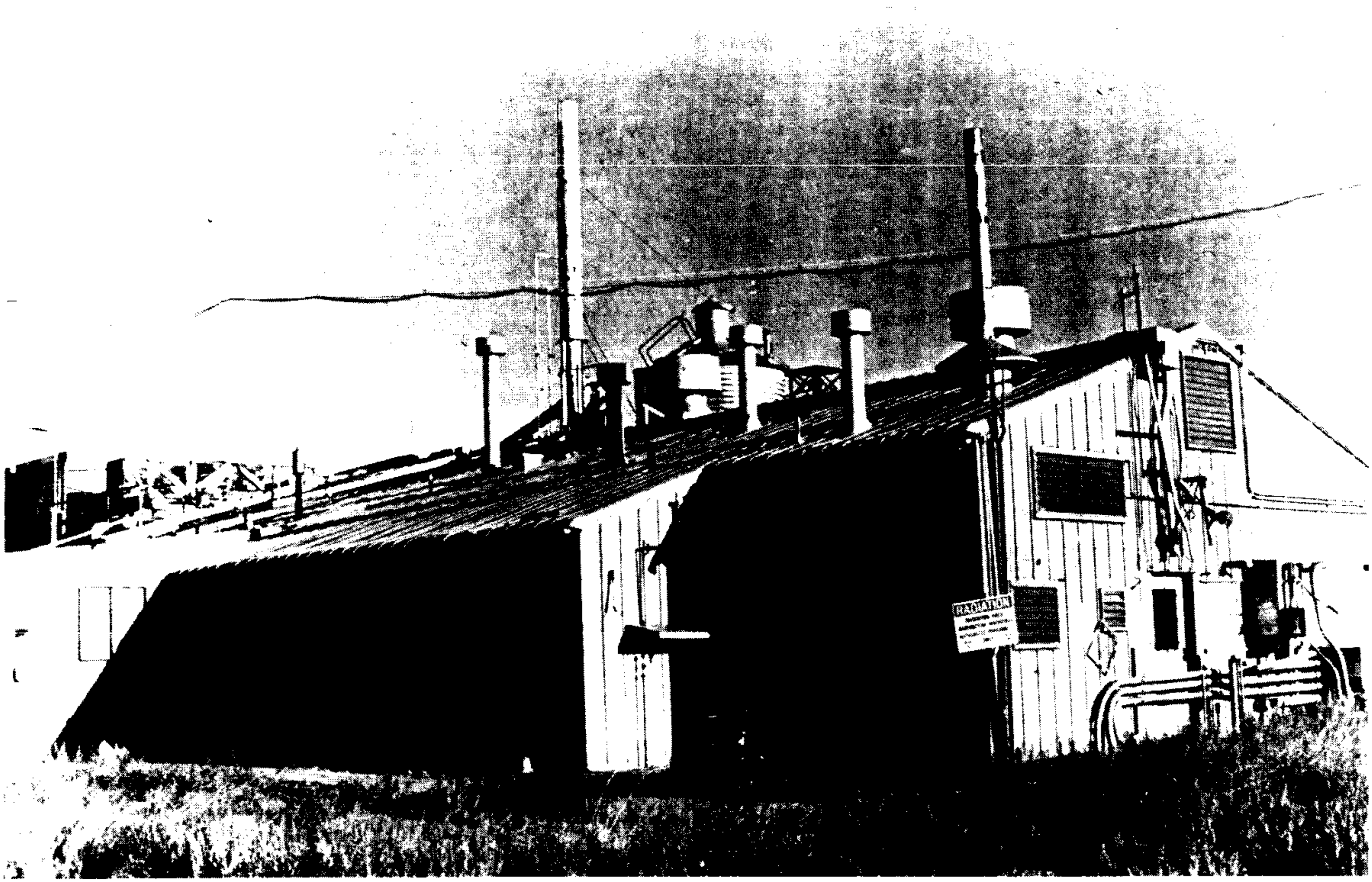


Figure 5. View of OMRE facility from the southeast.

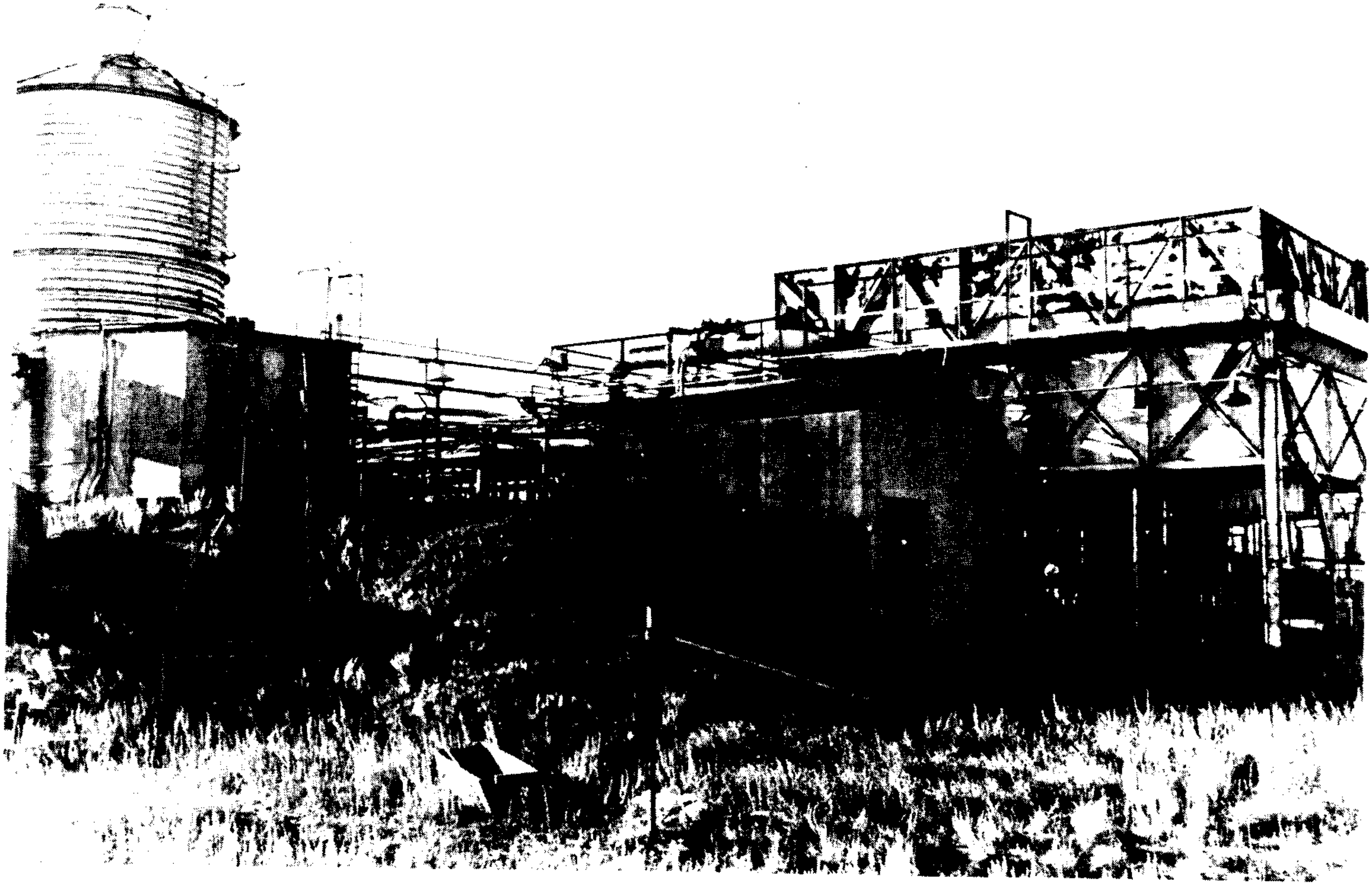


Figure 6. View of OMRE facility from the northwest.

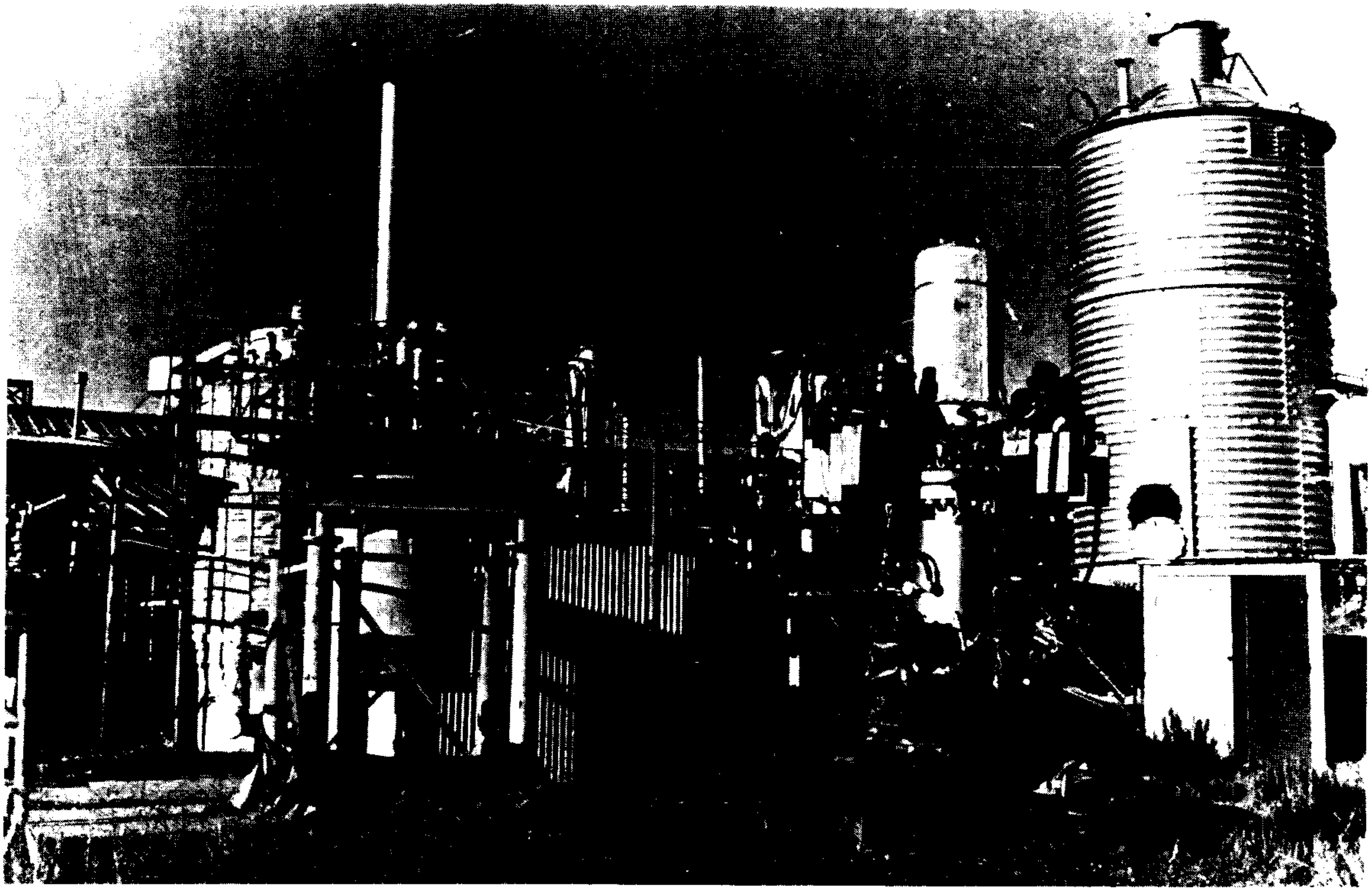


Figure 7. View of OMRE facility from the north.

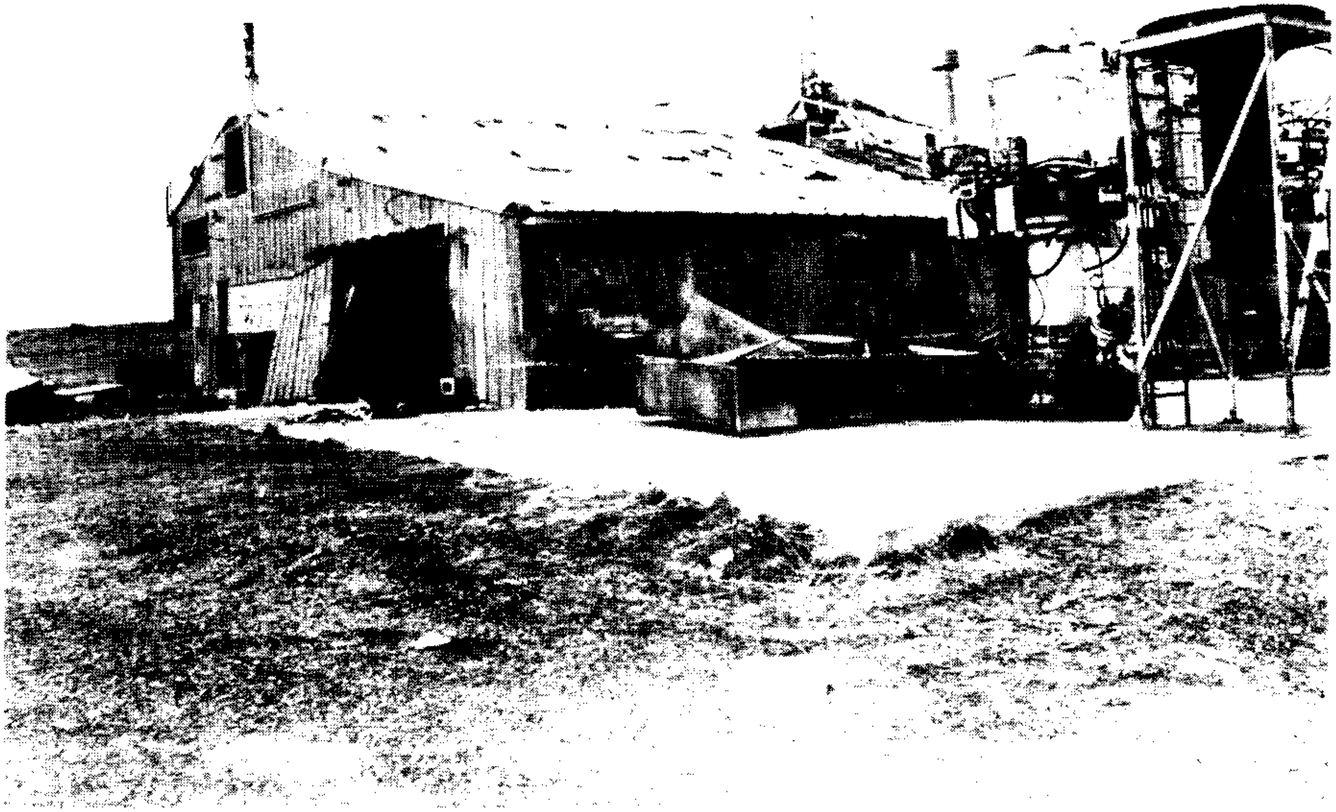


Figure 8. OMRE process and control building - view from the northeast.

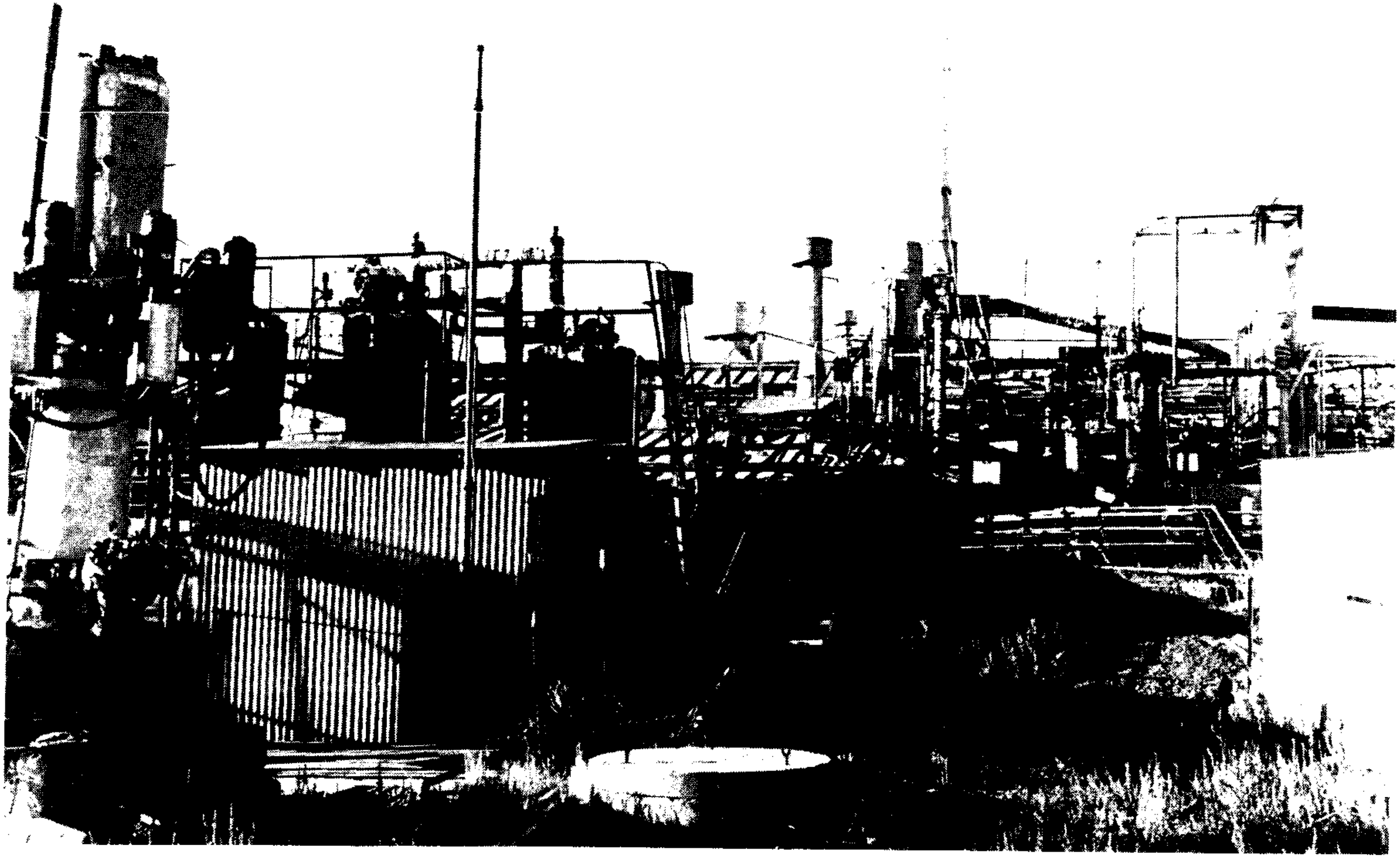


Figure 9. View of OMRE from the southwest.

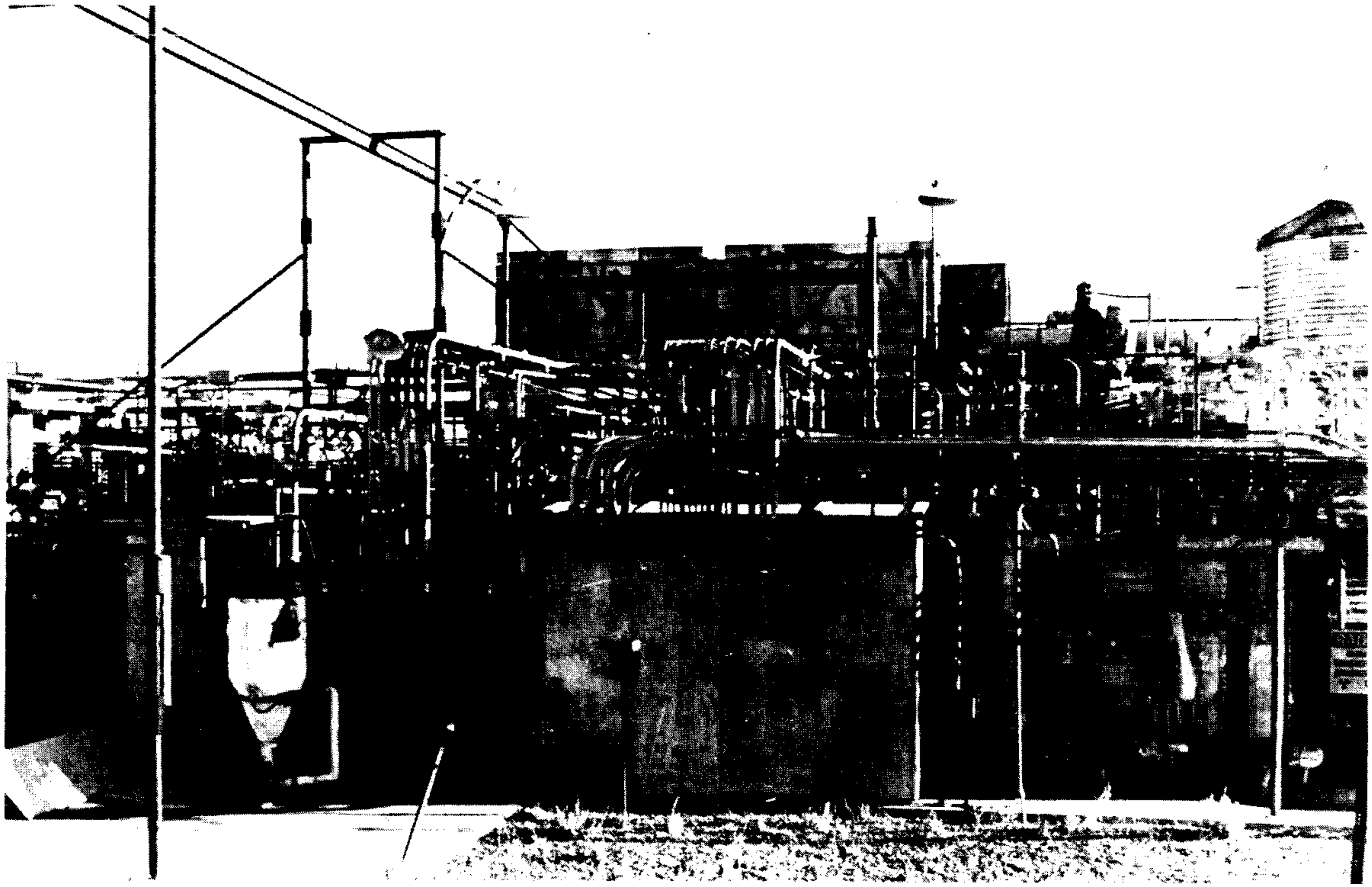


Figure 10. Impurities removal loop viewed from the south.

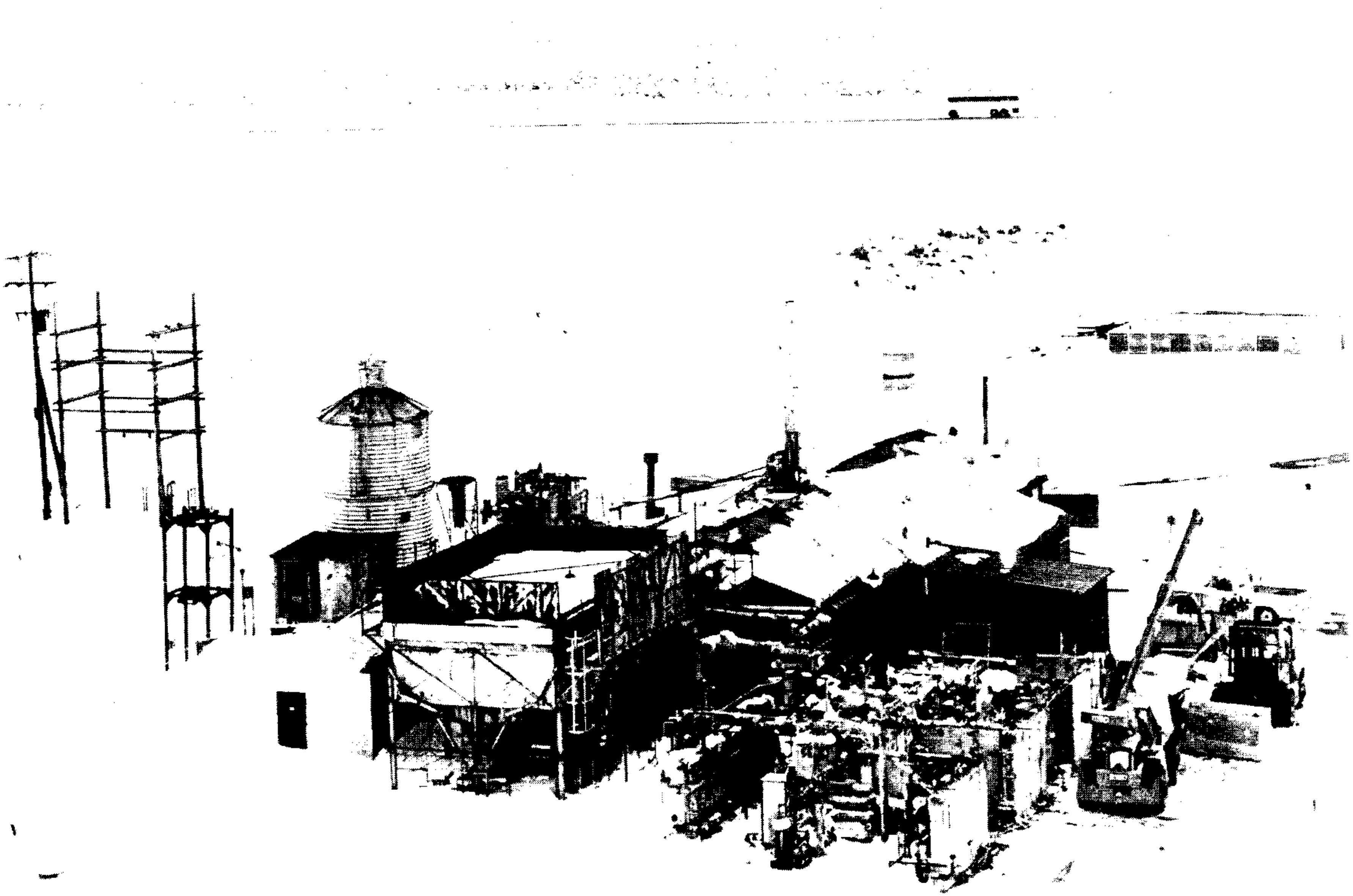


Figure 11. OMRE facility overview from the west.

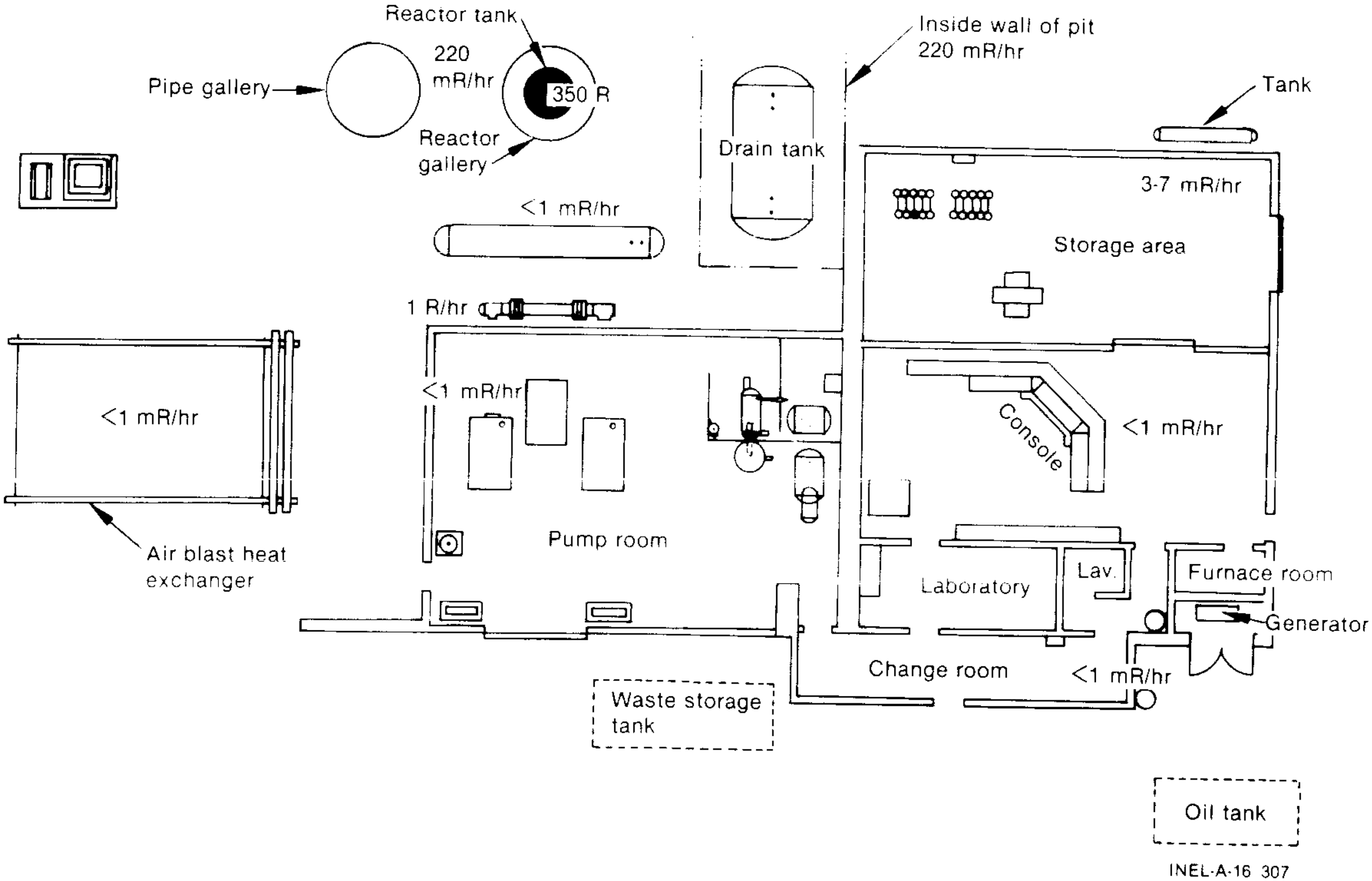


Figure 12. OMRE radiation map plan.

Figure 13. Salvageable scrap material.

Figure 14. Miscellaneous equipment in the process equipment building.

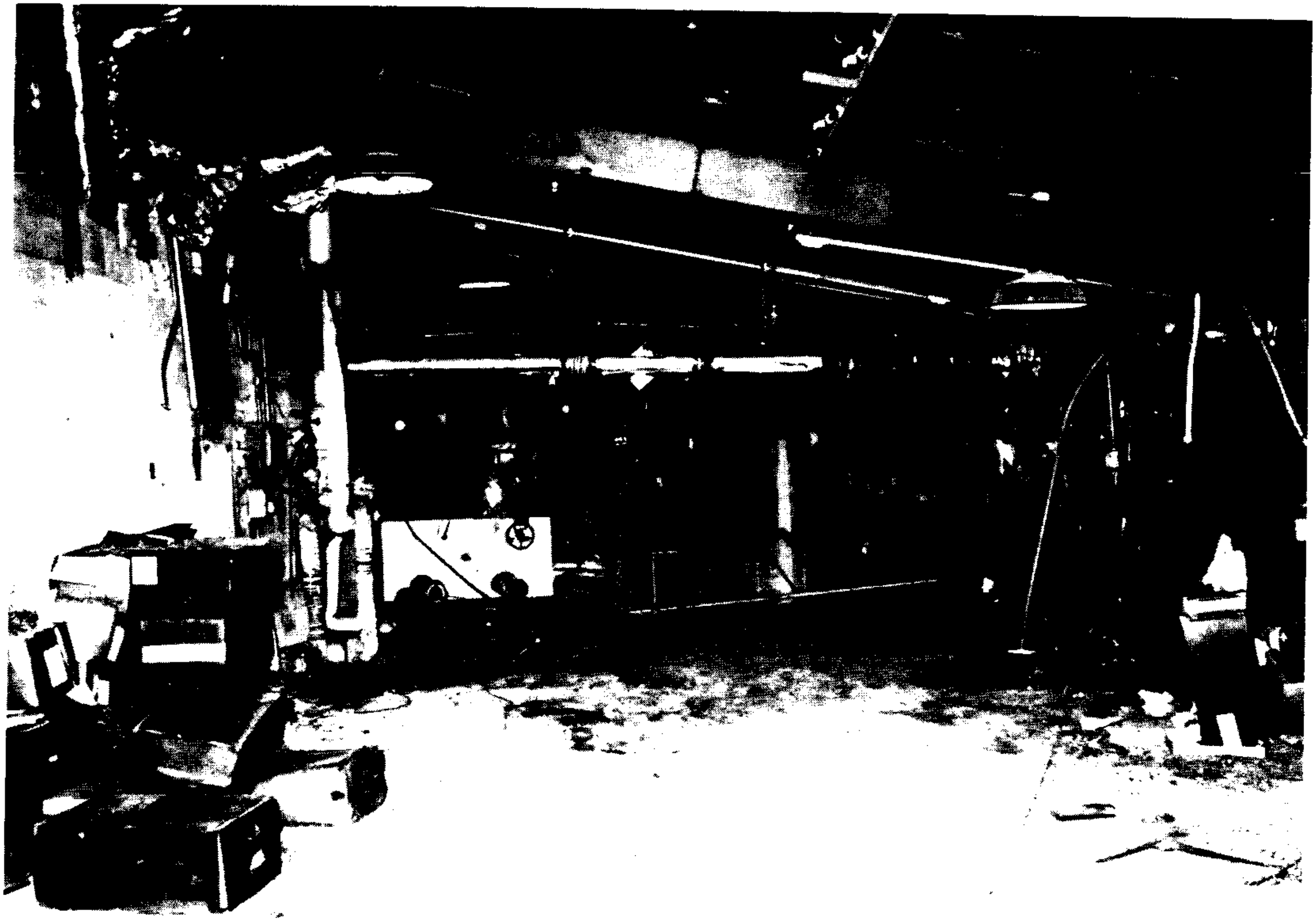


Figure 15. Inside equipment storage and work area.

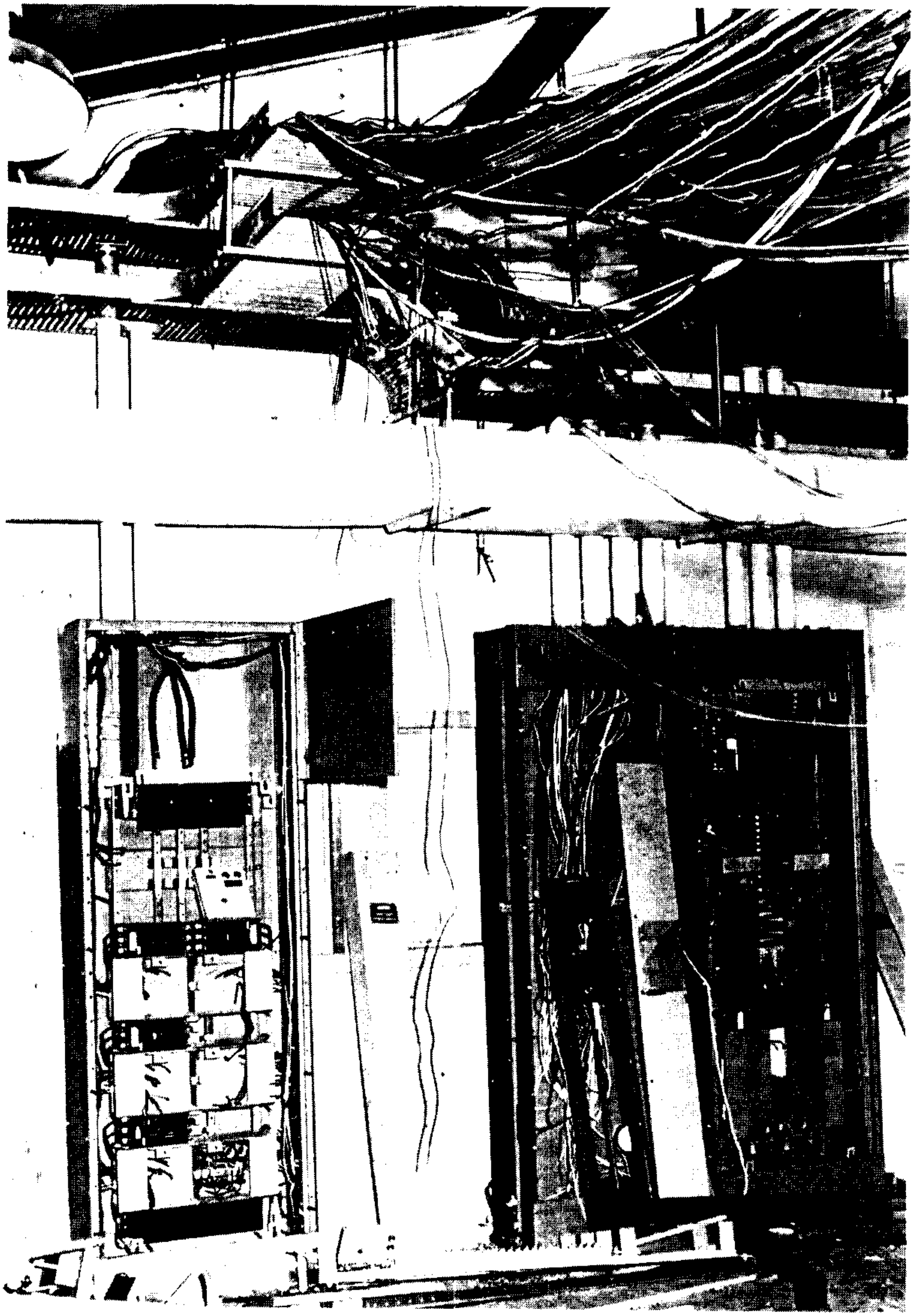


Figure 16. Control room electrical equipment.

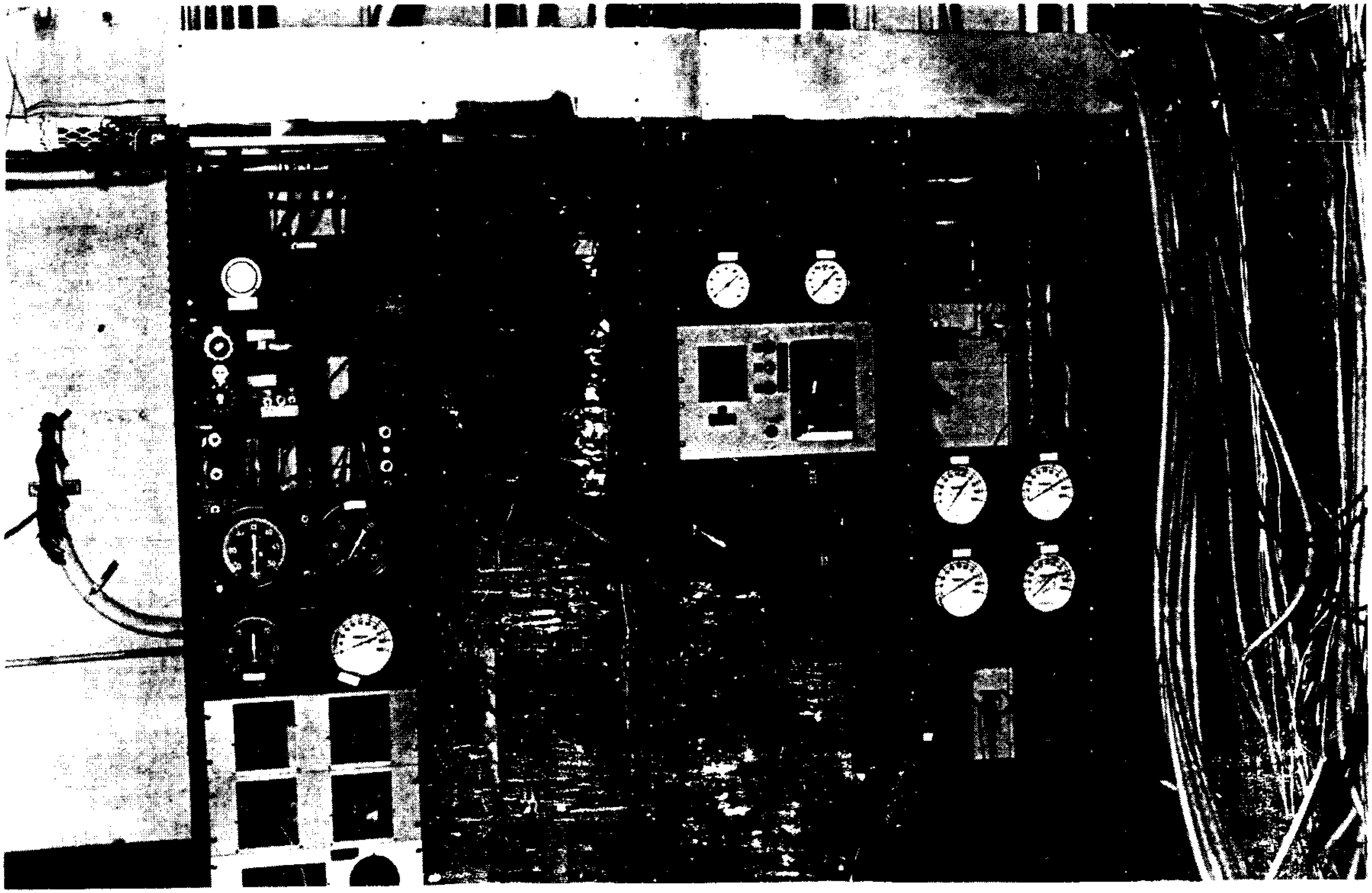


Figure 17. Control room instrument panels.

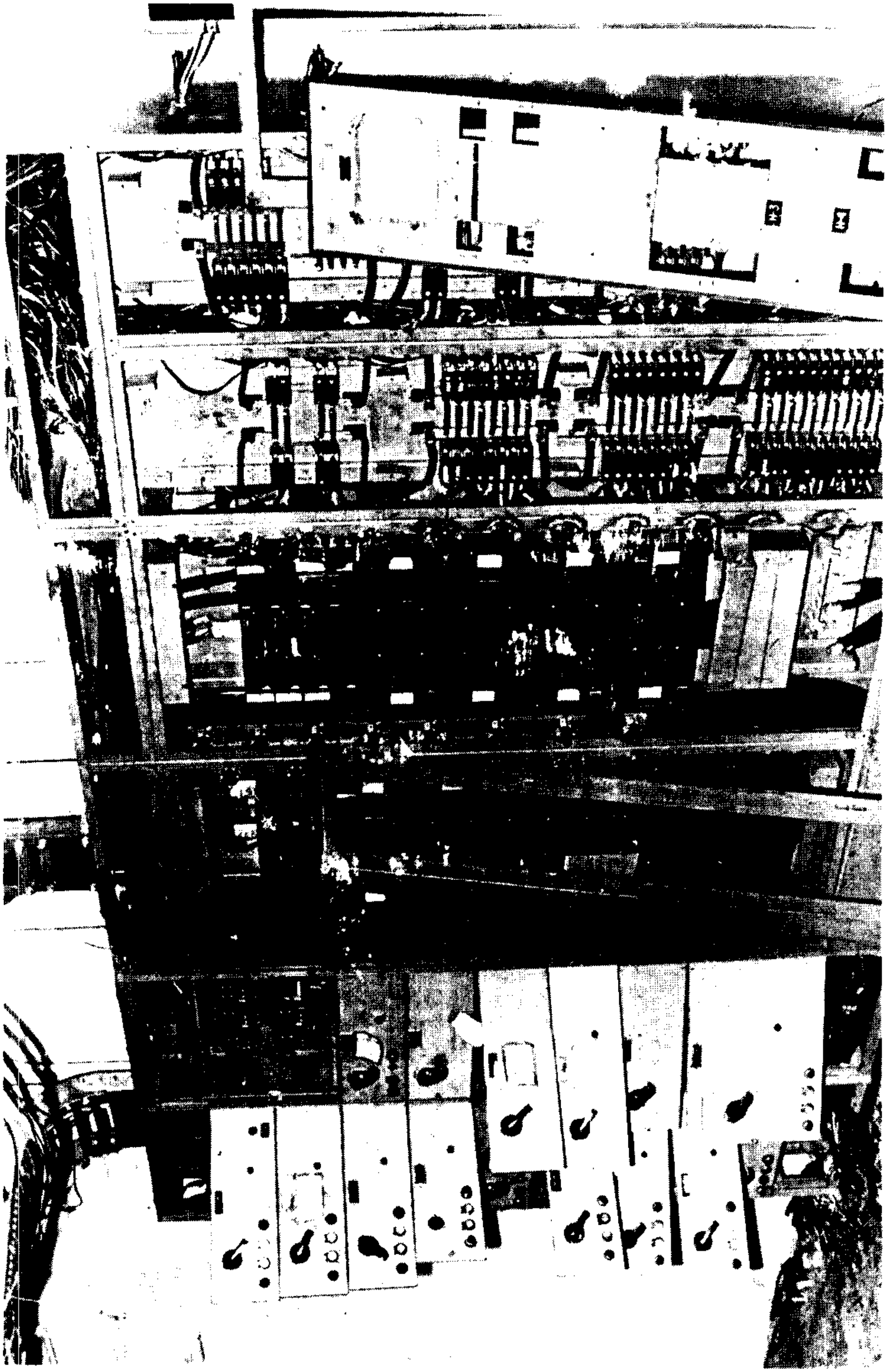


Figure 18. Control room breaker panels.

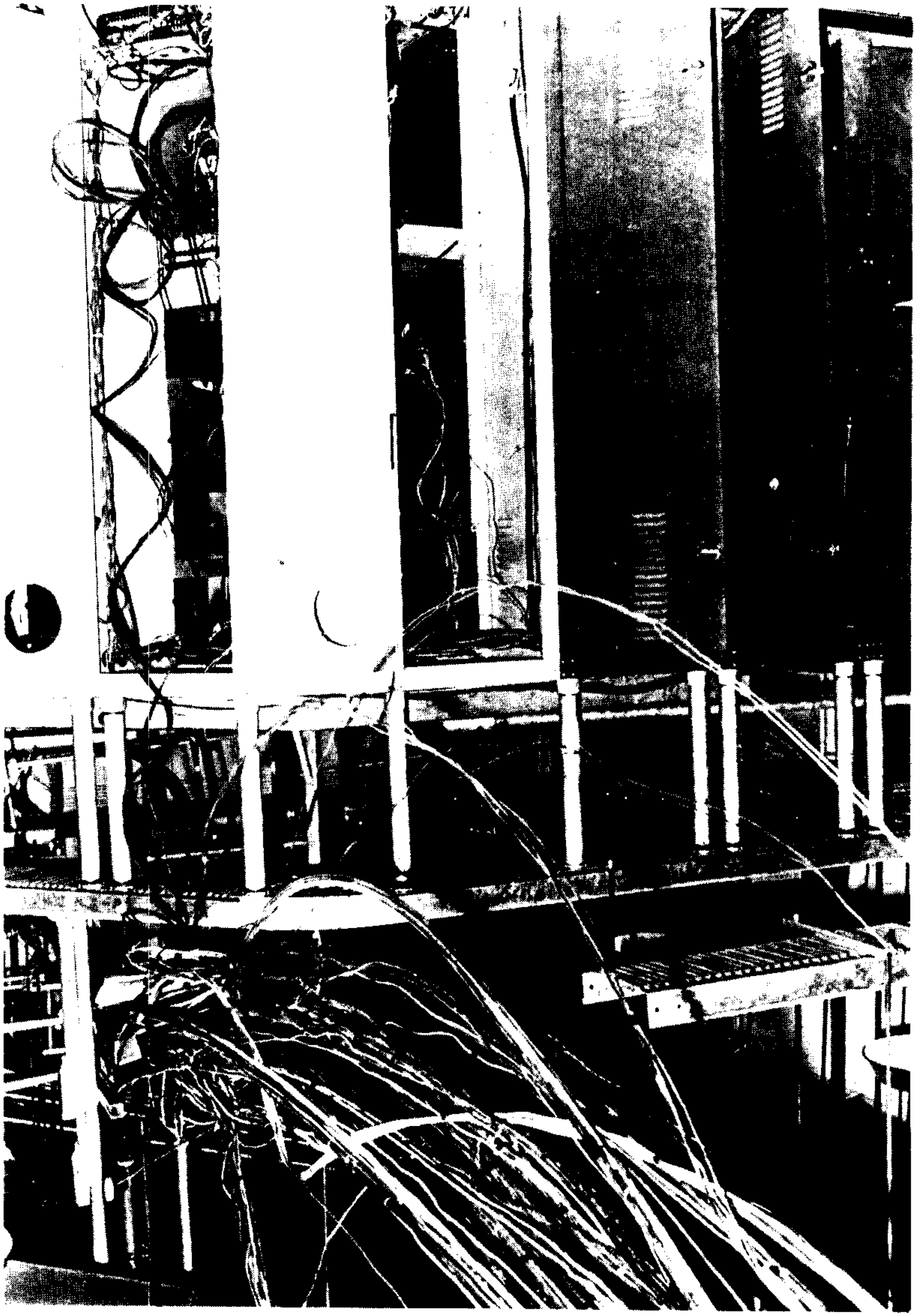


Figure 19. Control room panels, cableways, and cabling.

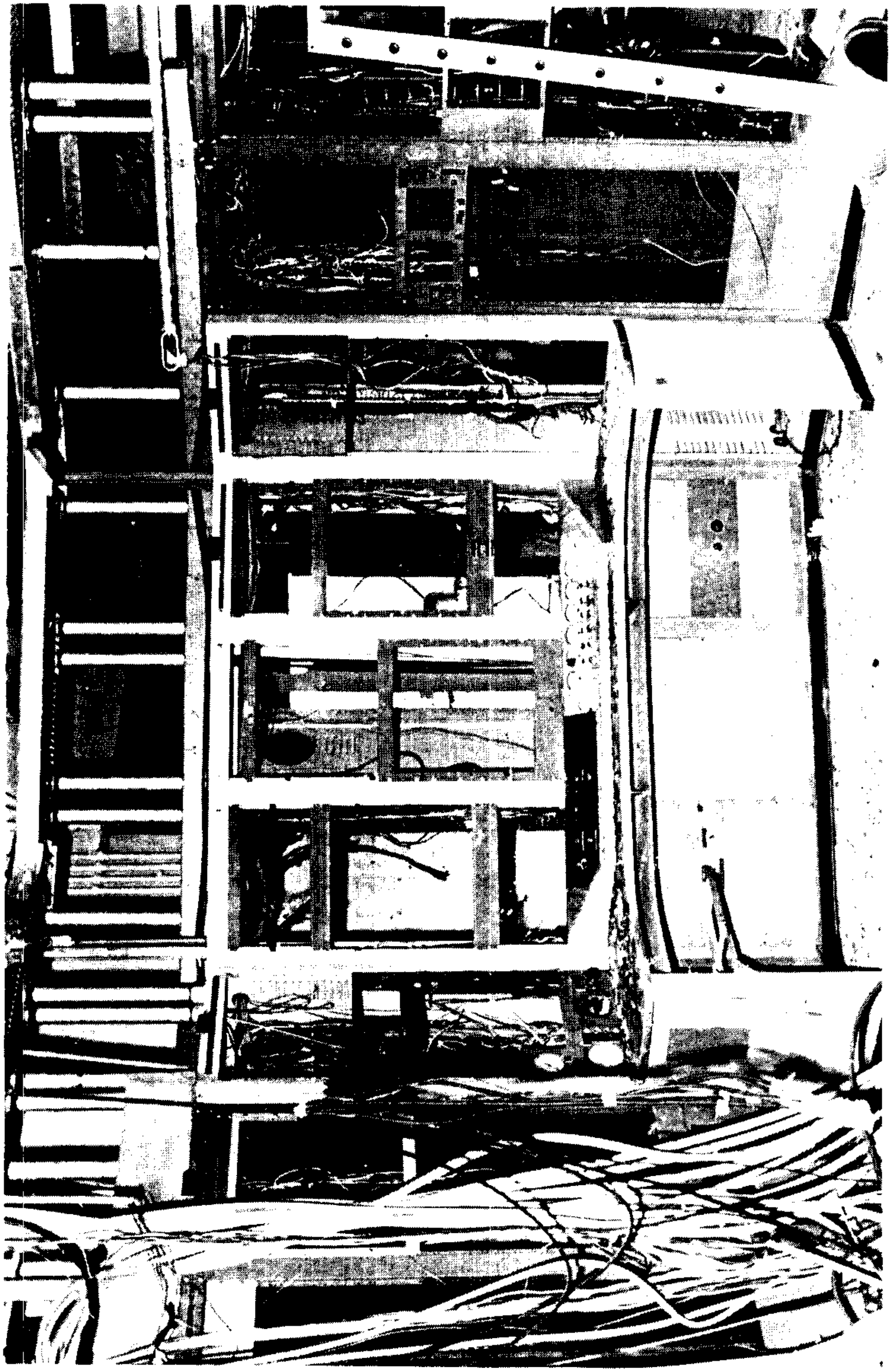


Figure 20. Control console.

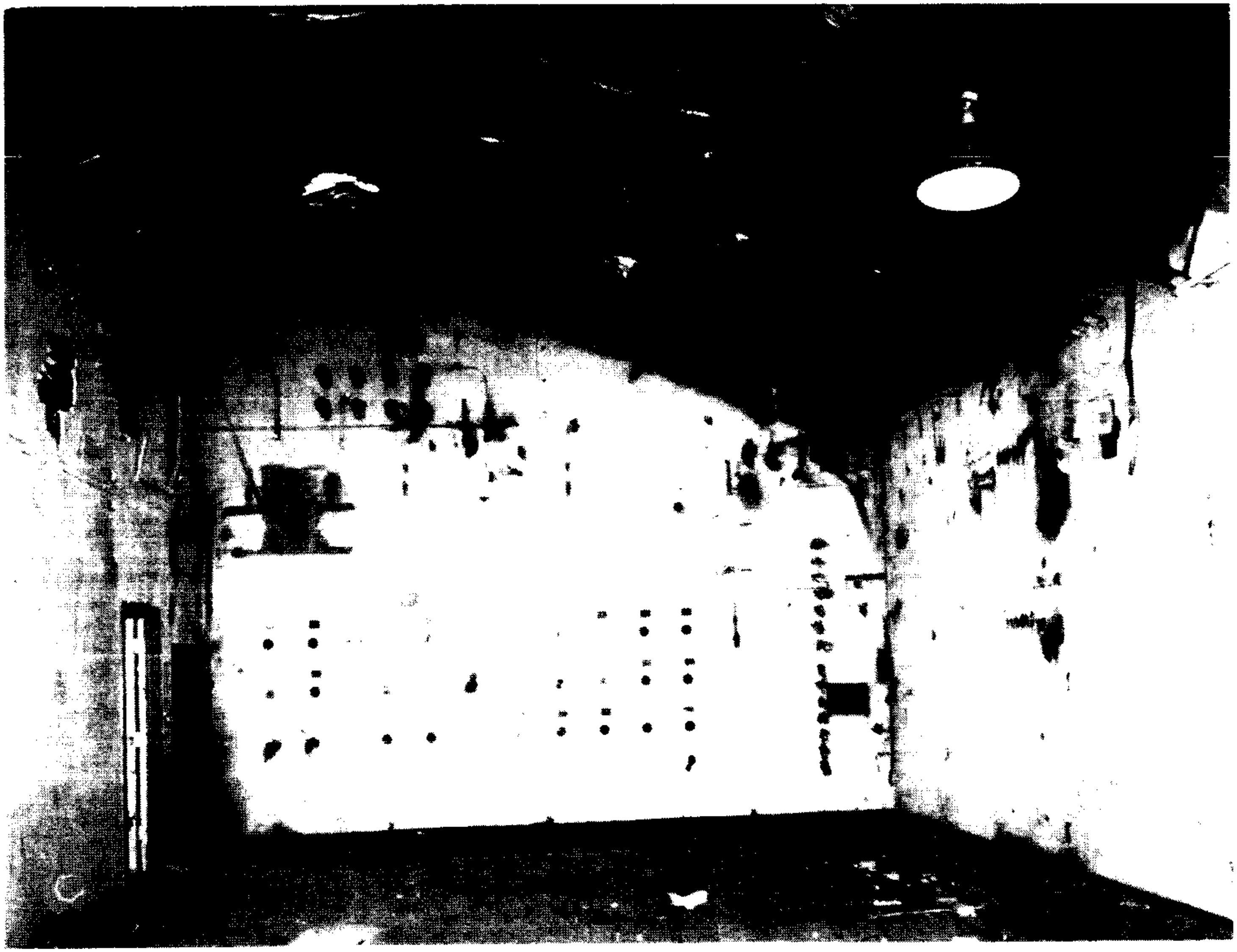


Figure 21. Control room after electrical systems removal.

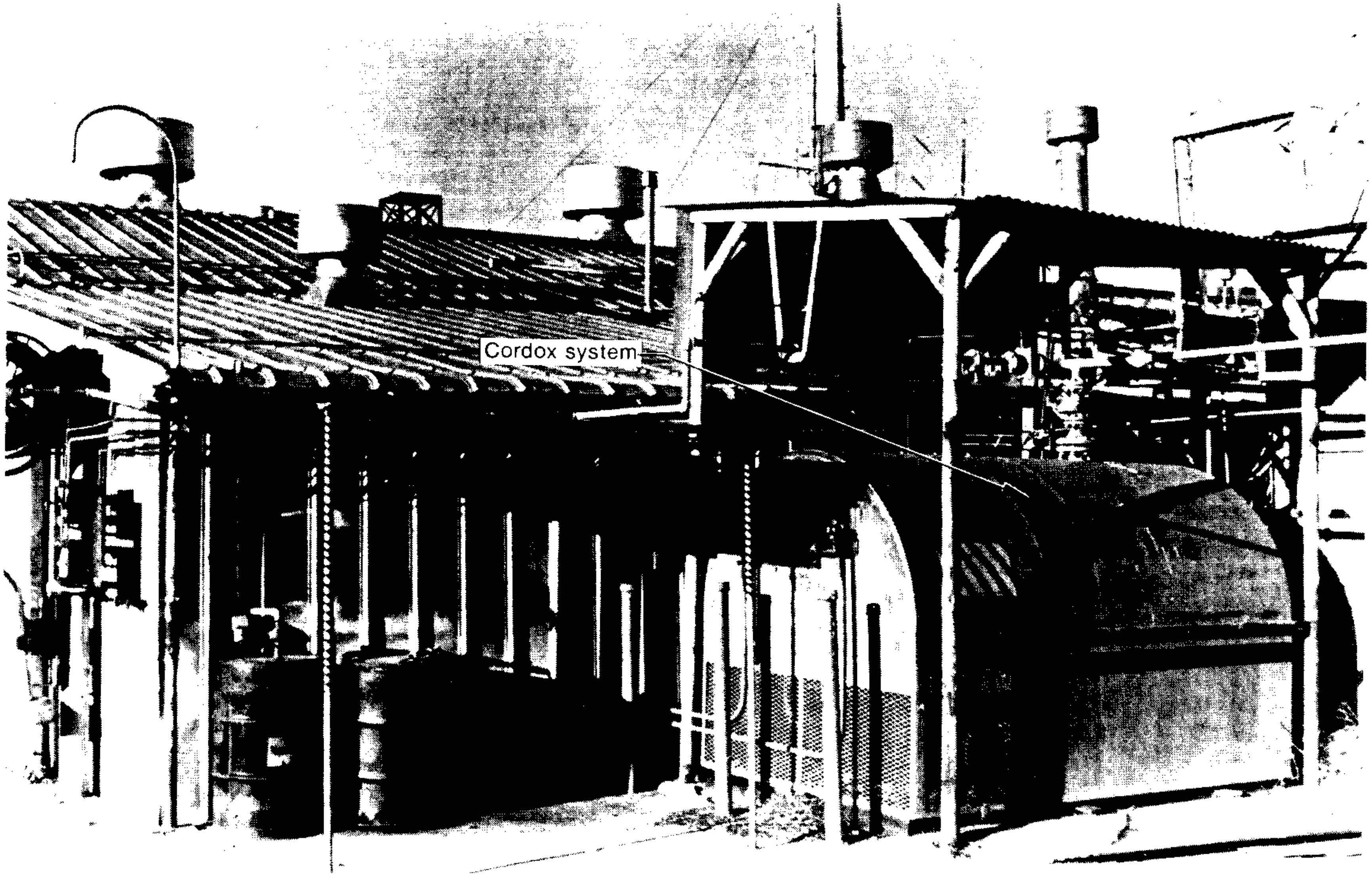


Figure 22. View of OMRE facility from the northeast.

Figure 23. Main loop piping located in the process equipment building.

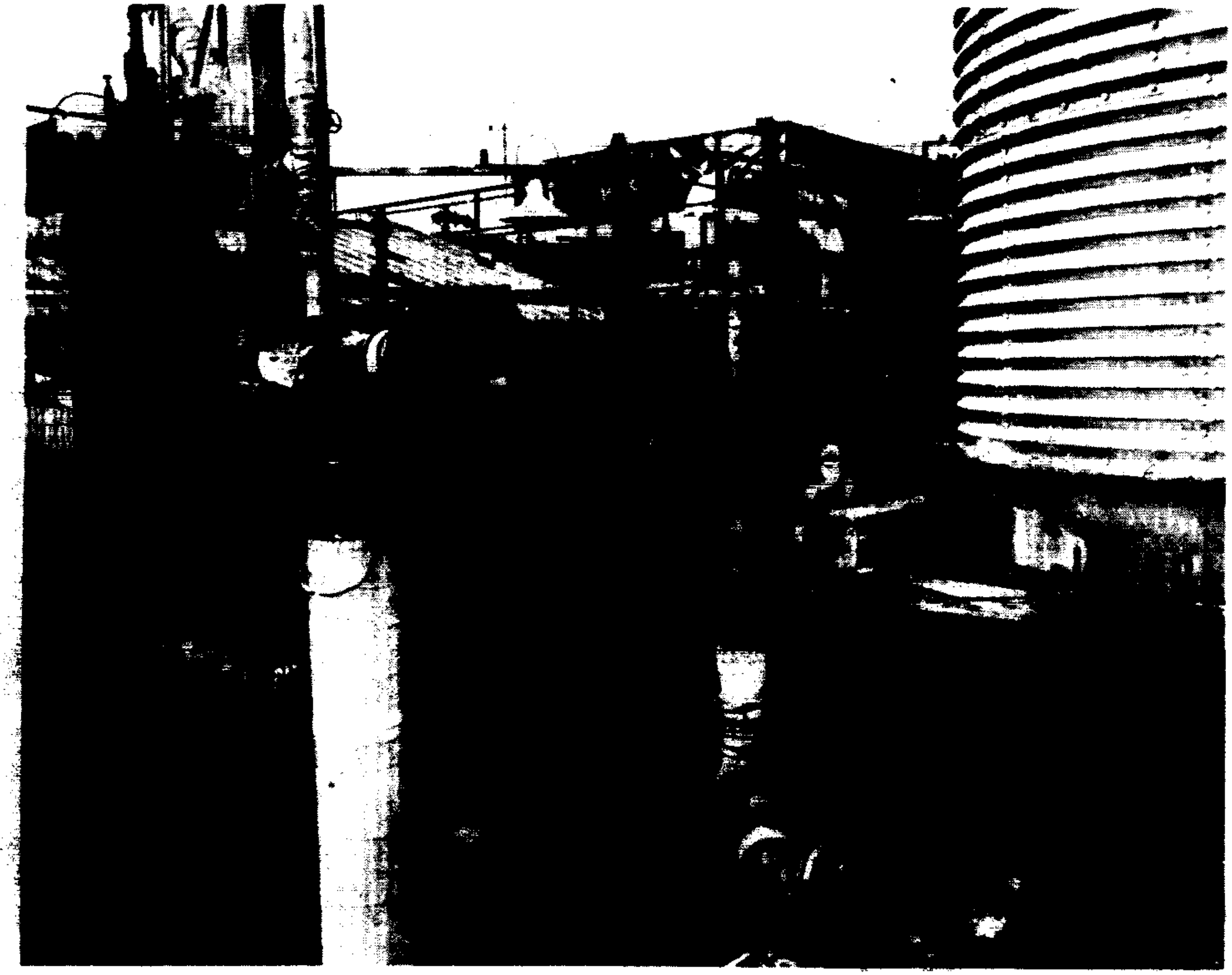


Figure 24. Main loop sediment tank and filtration systems.

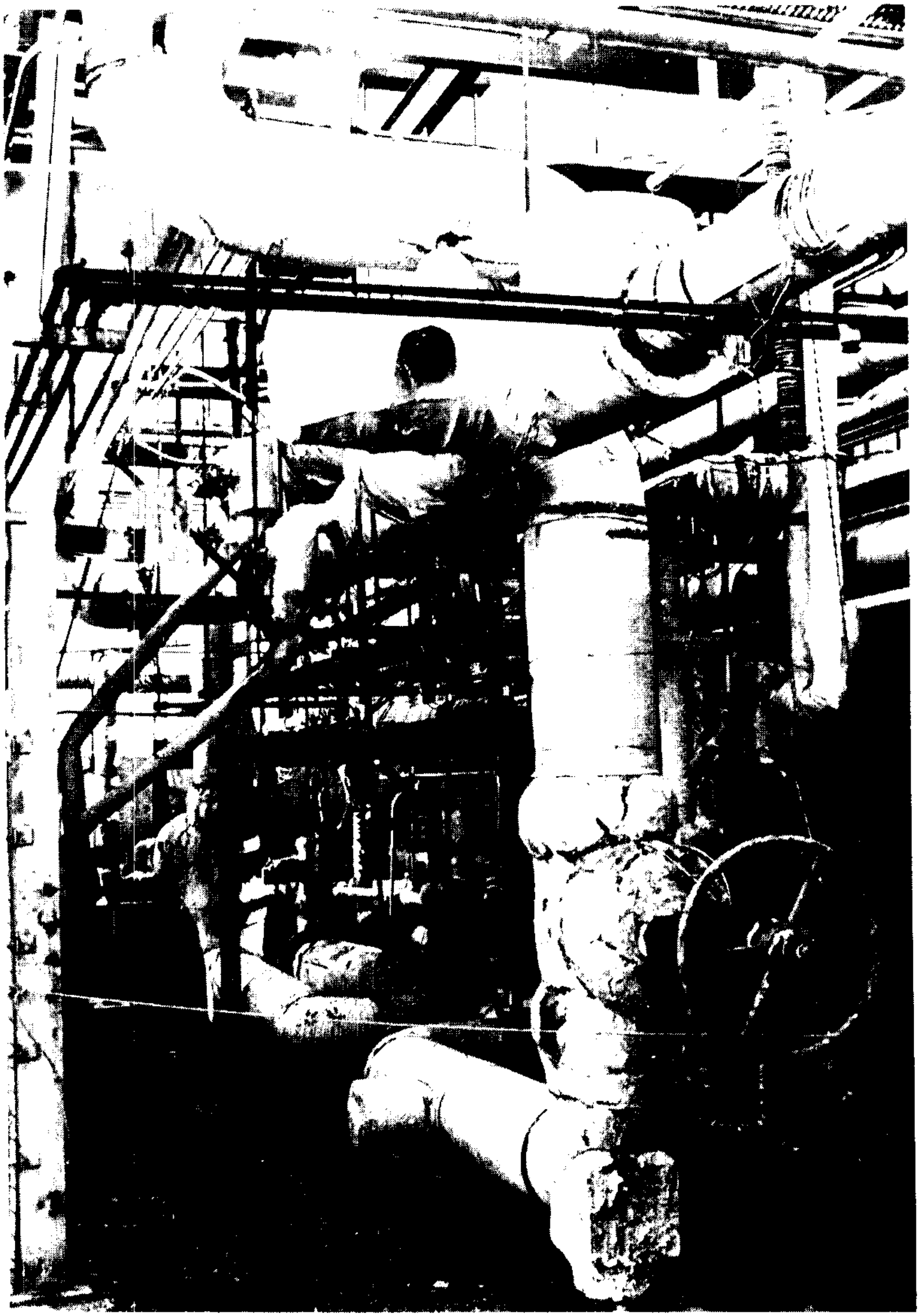


Figure 25. Main loop piping connecting air blast heat exchanger, reactor, and main loop components.

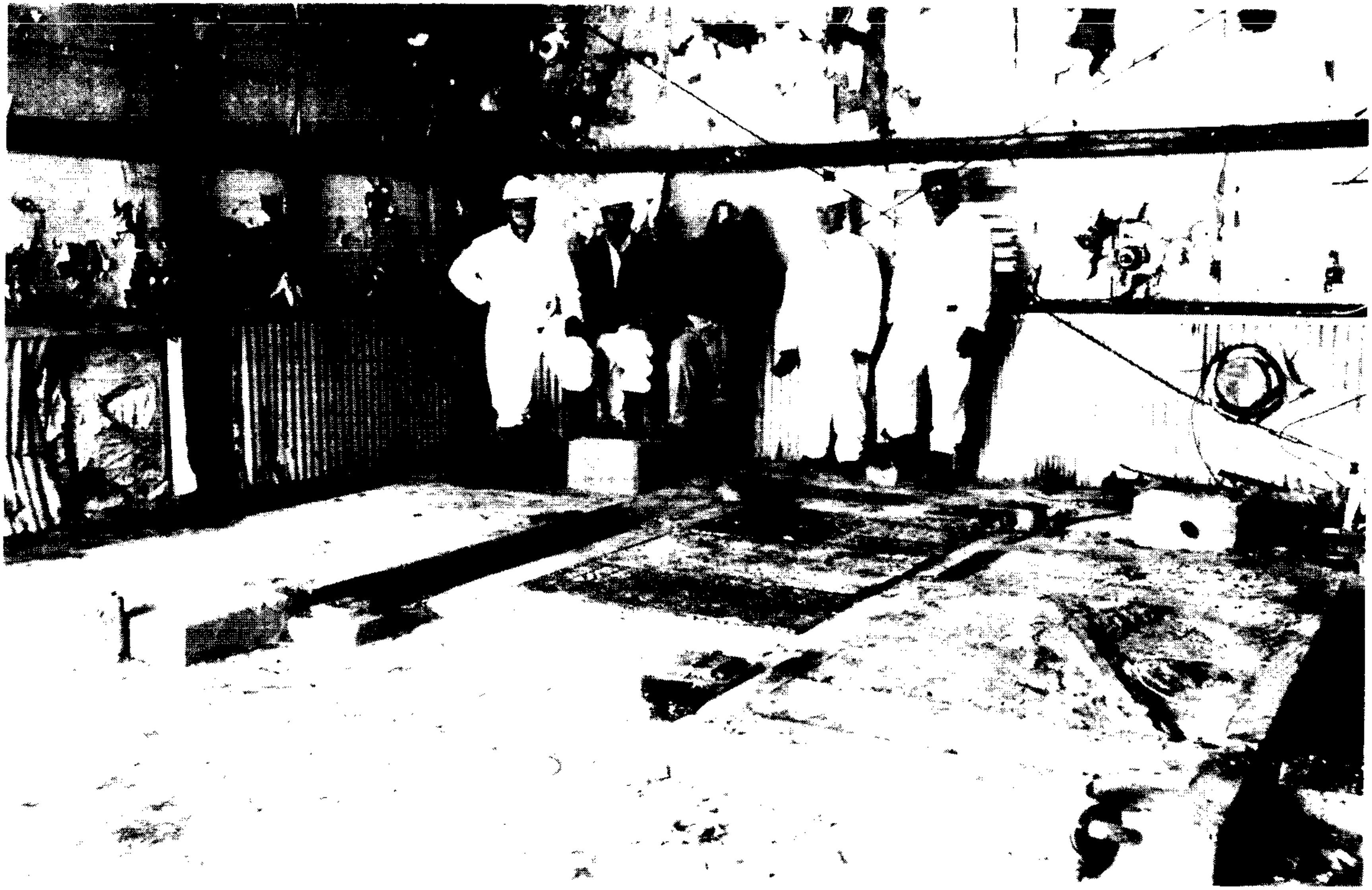


Figure 26. Main loop piping area in process equipment building — after removal.

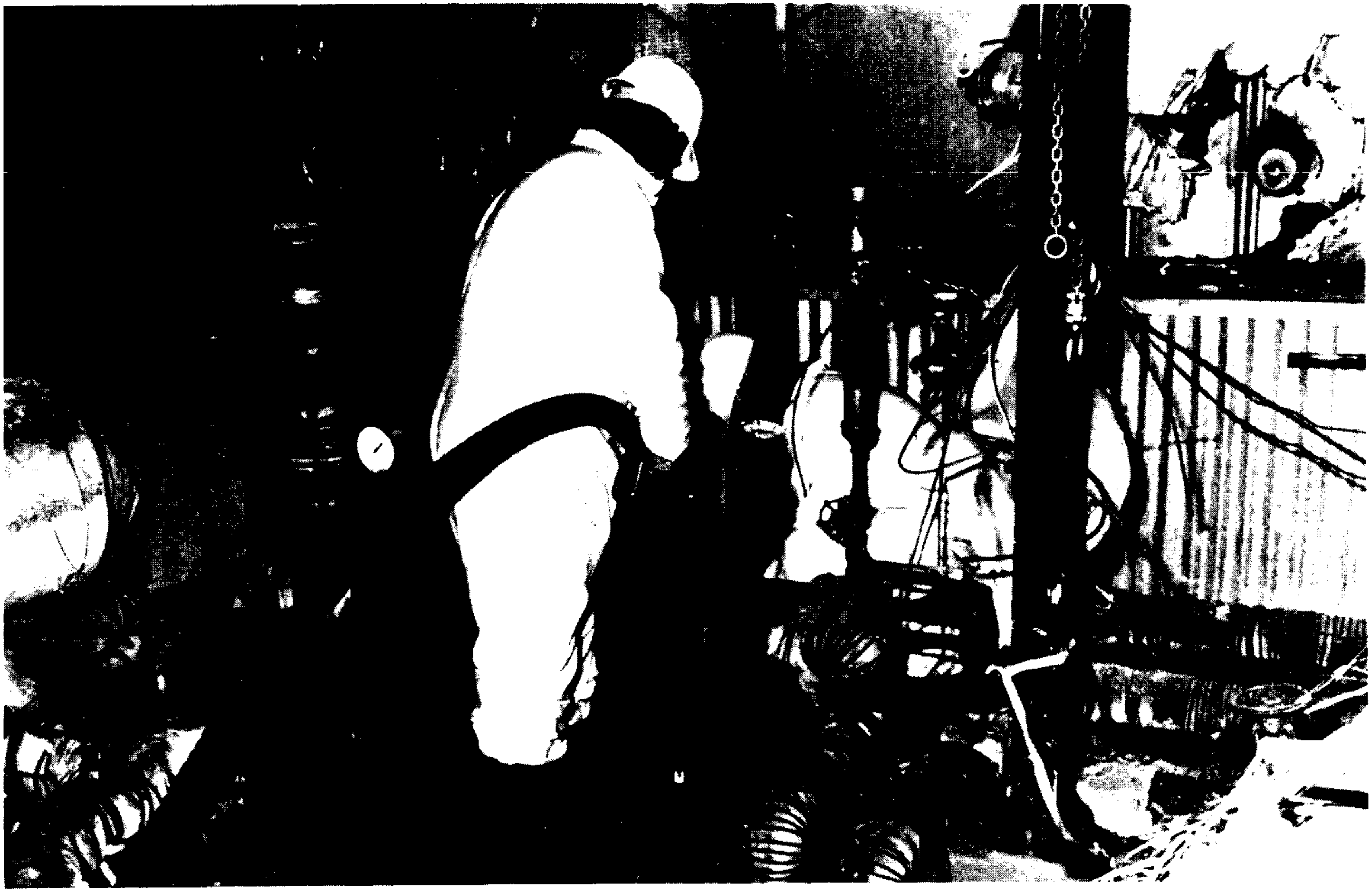


Figure 27. Removing asbestos insulation from piping prior to cutting pipe.

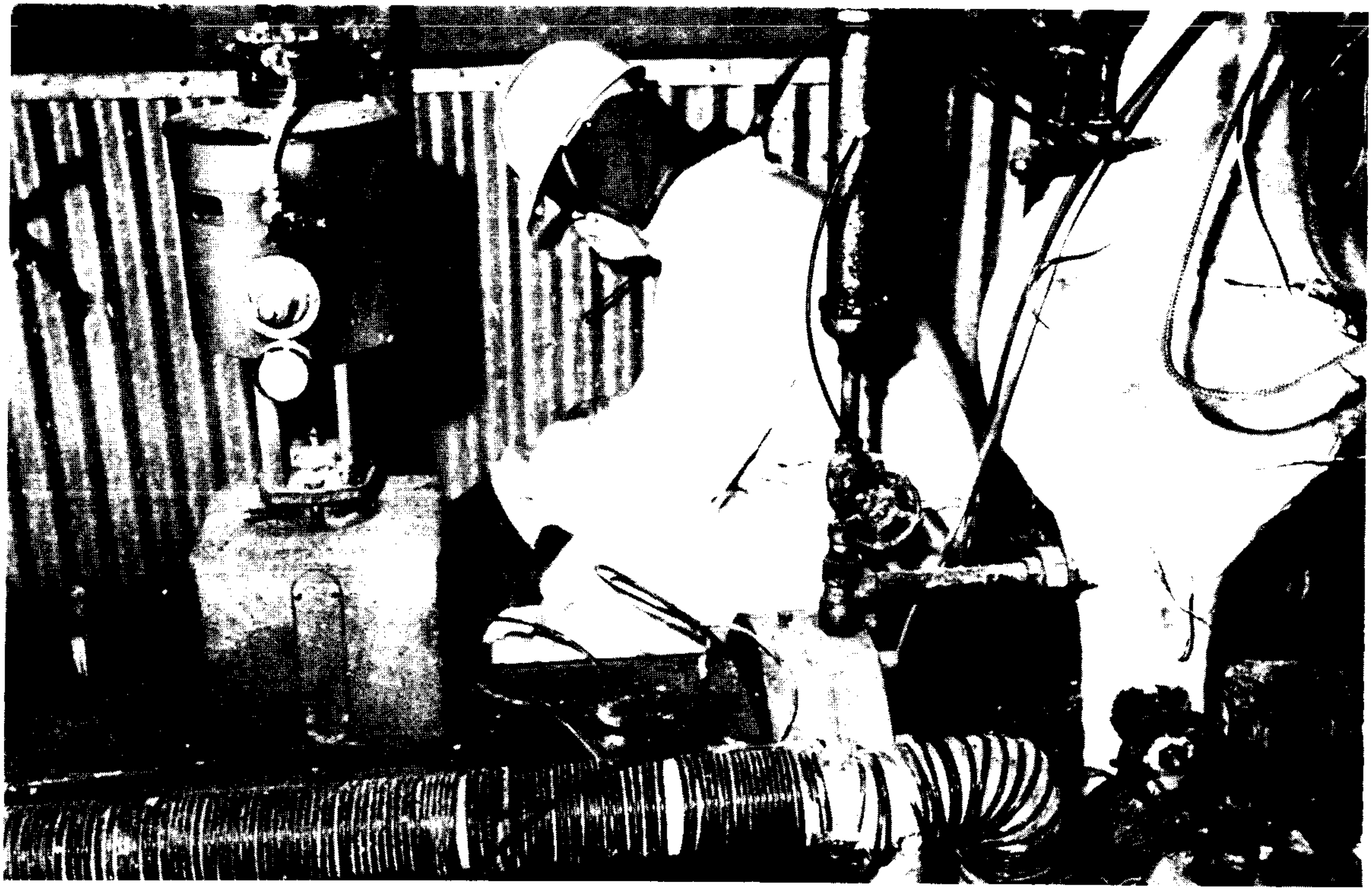


Figure 28. Removing heat tracing from piping prior to cutting pipe.

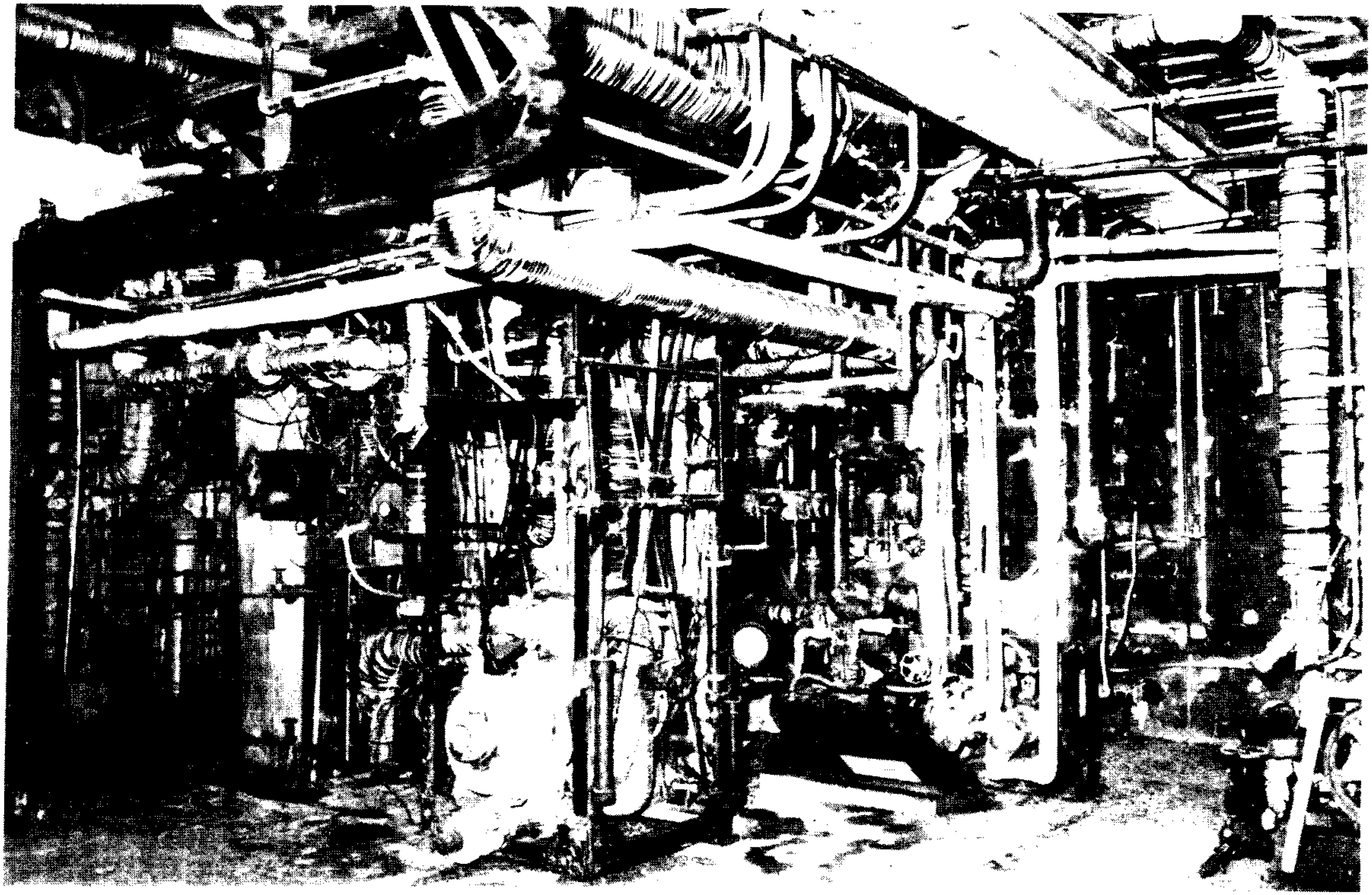


Figure 29. Purification system equipment located in the process and control building.

Figure 30. Purification system piping in the process and control building pit.

Figure 31. Process and control building pit after removal of purification system piping.

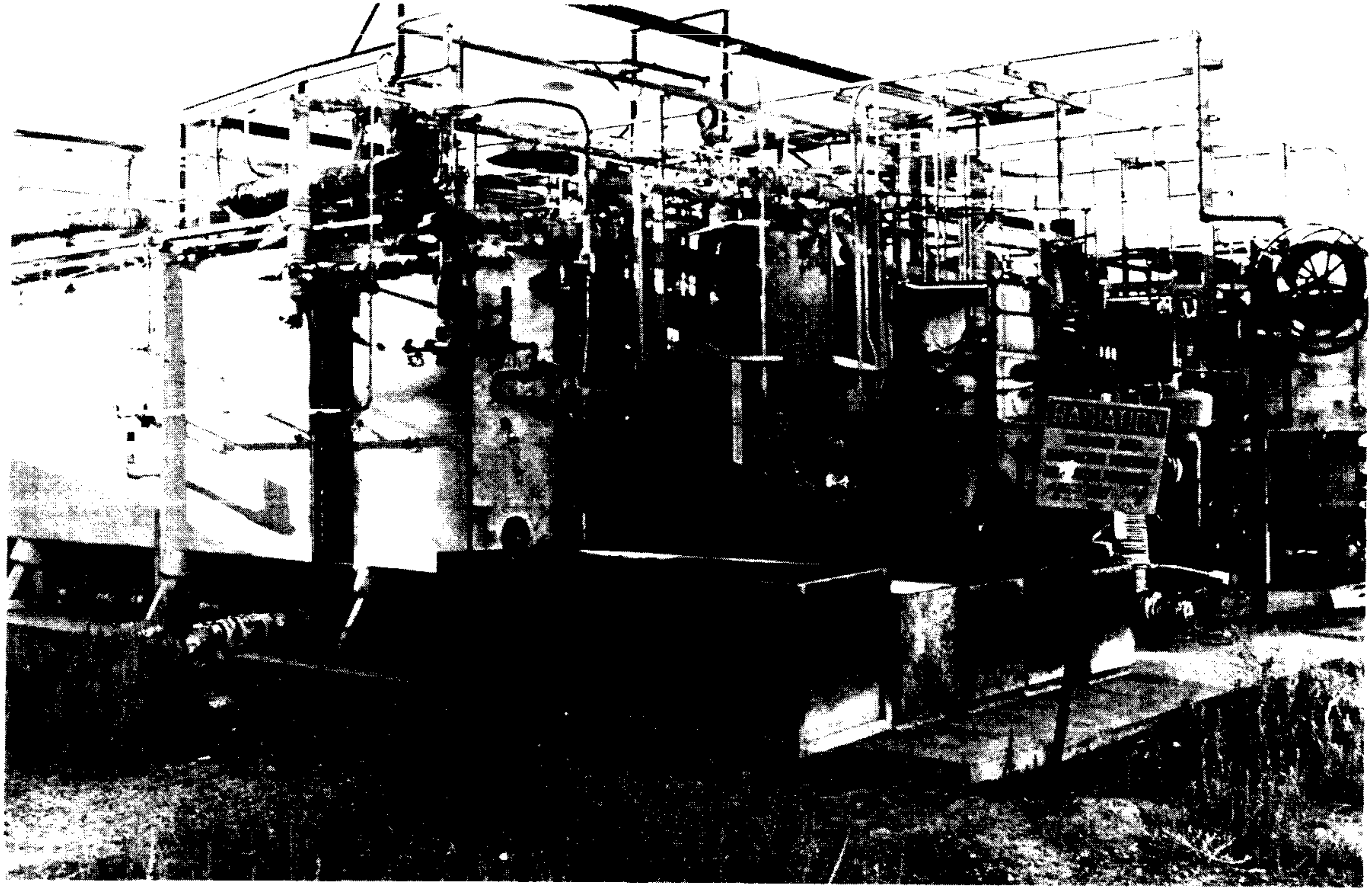


Figure 32. IRL system viewed from northwest.

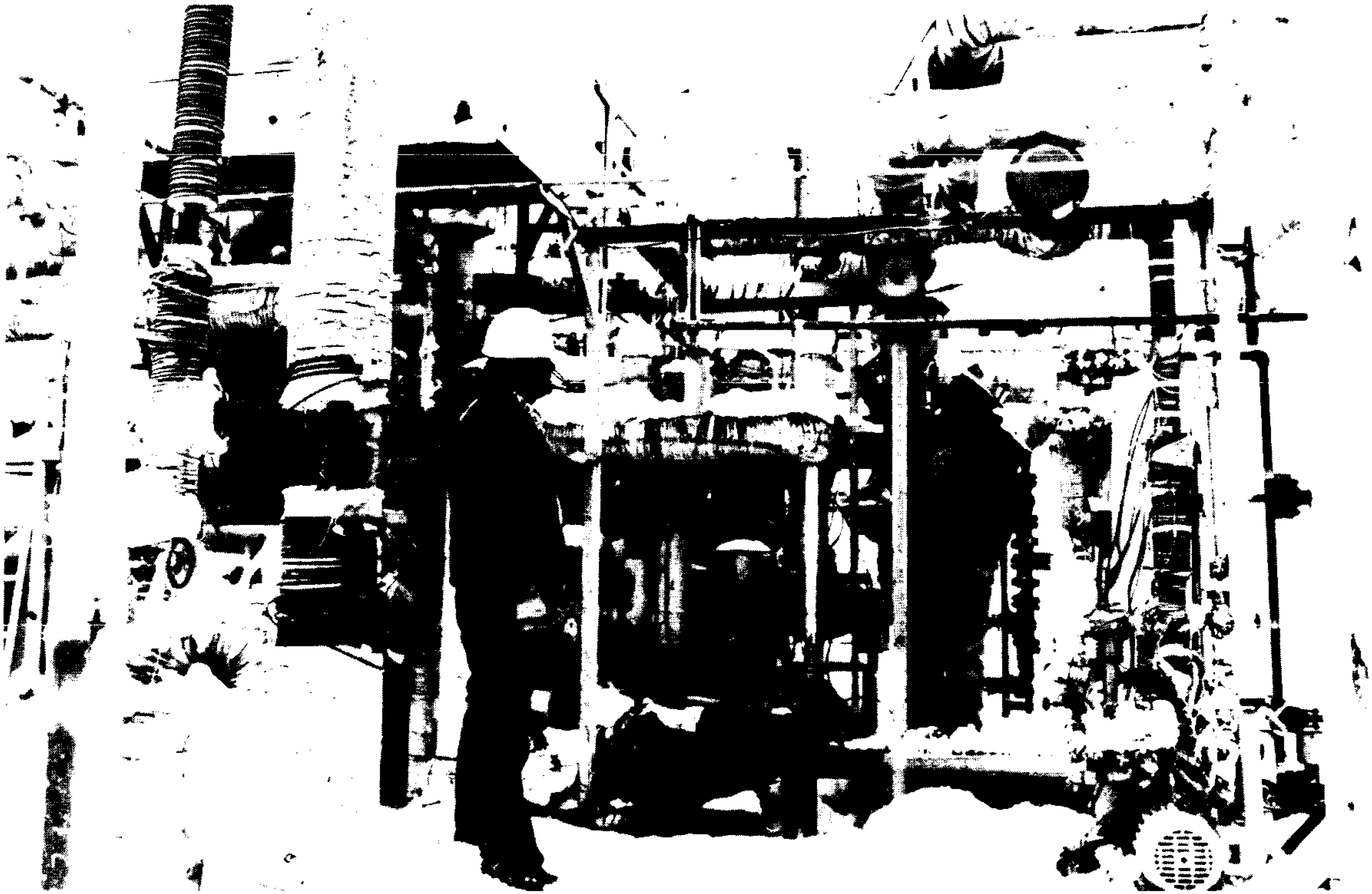


Figure 33. Removal of IRL equipment.

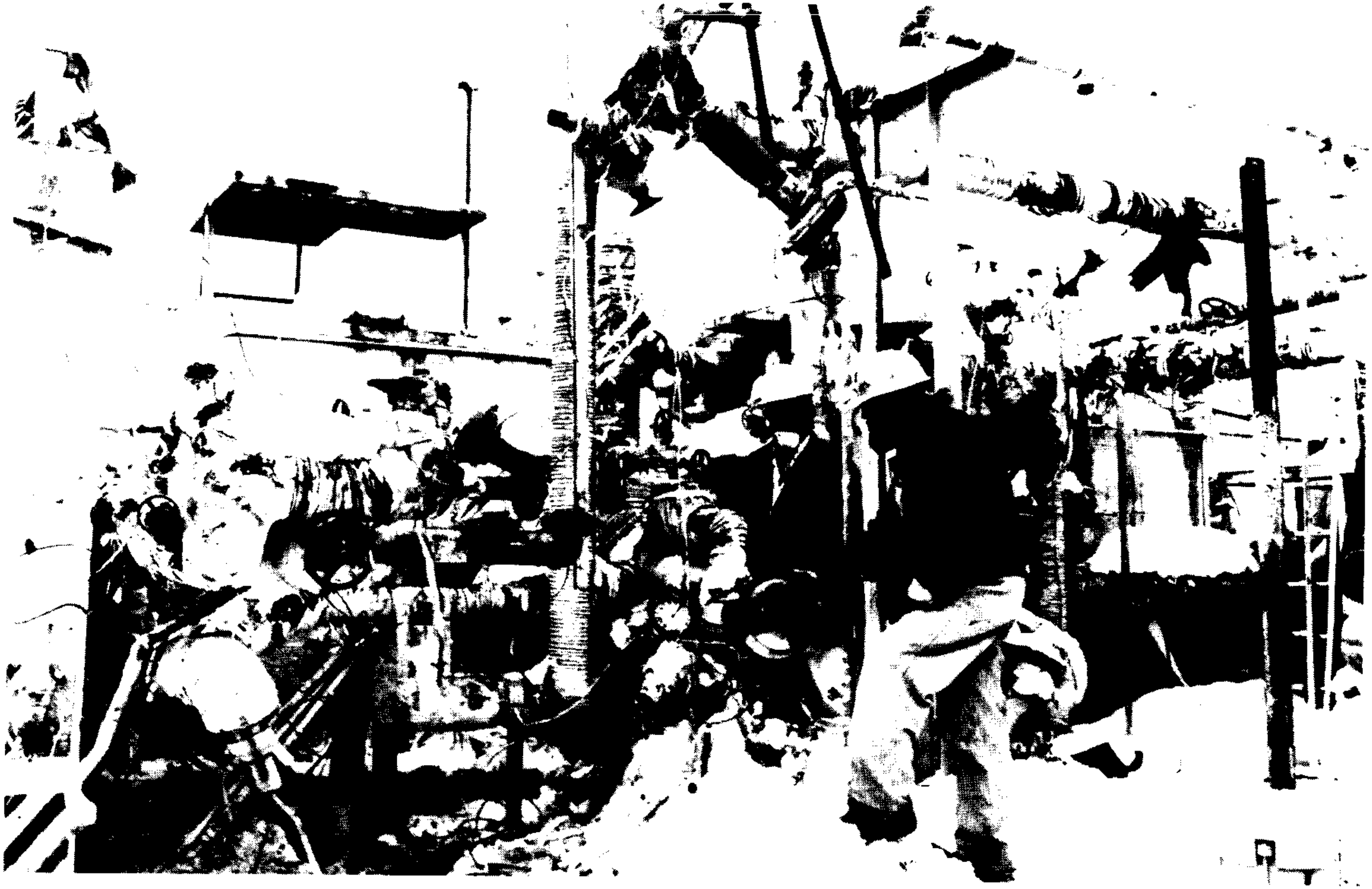


Figure 34. IRL dismantling in progress.

Figure 35. Work proceeds outside on IRL pad despite snow and cold weather.

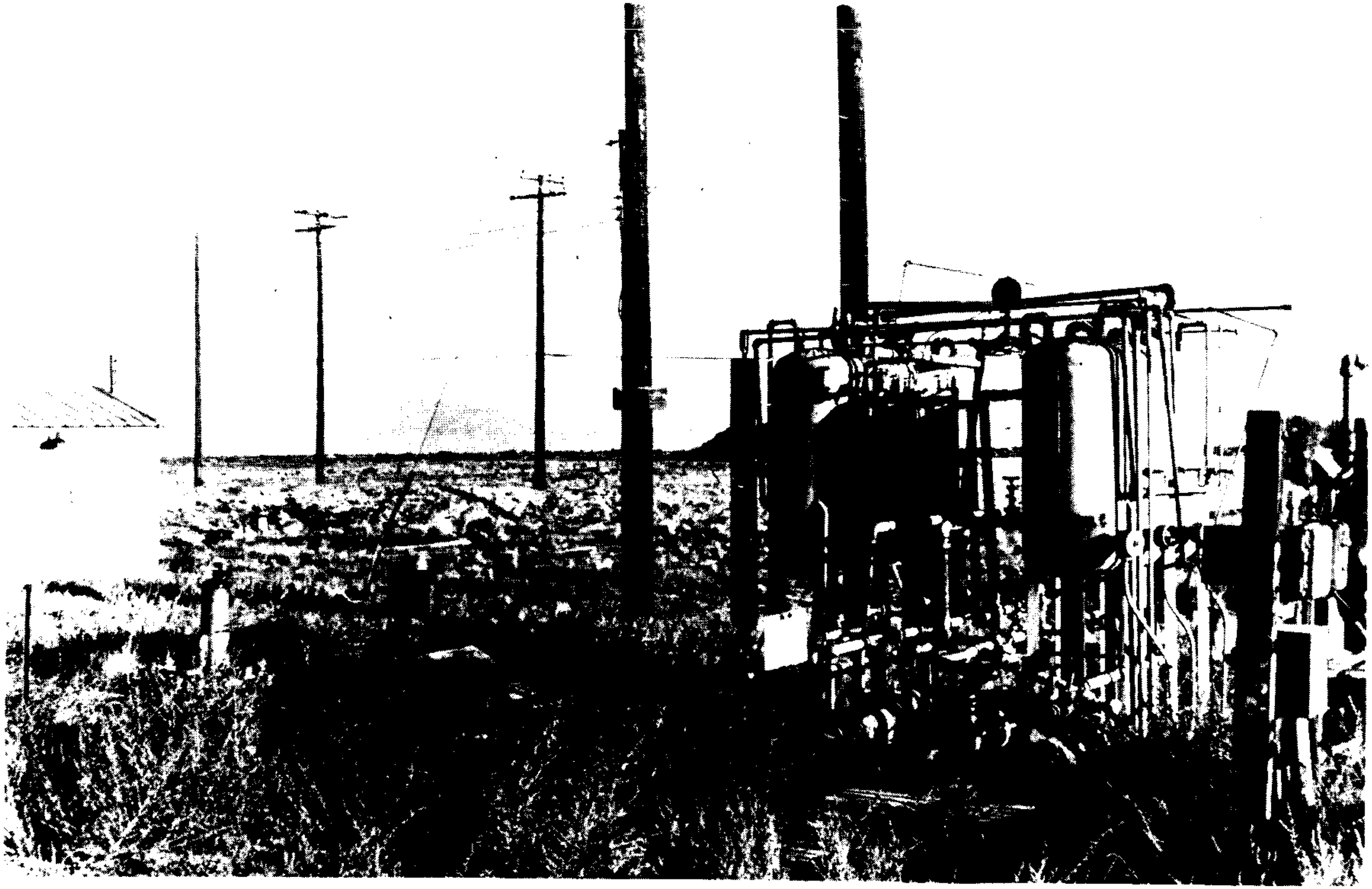


Figure 36. Fuel wash system—deep well pumphouse.

Figure 37. Starting disassembly of air blast heat exchanger.

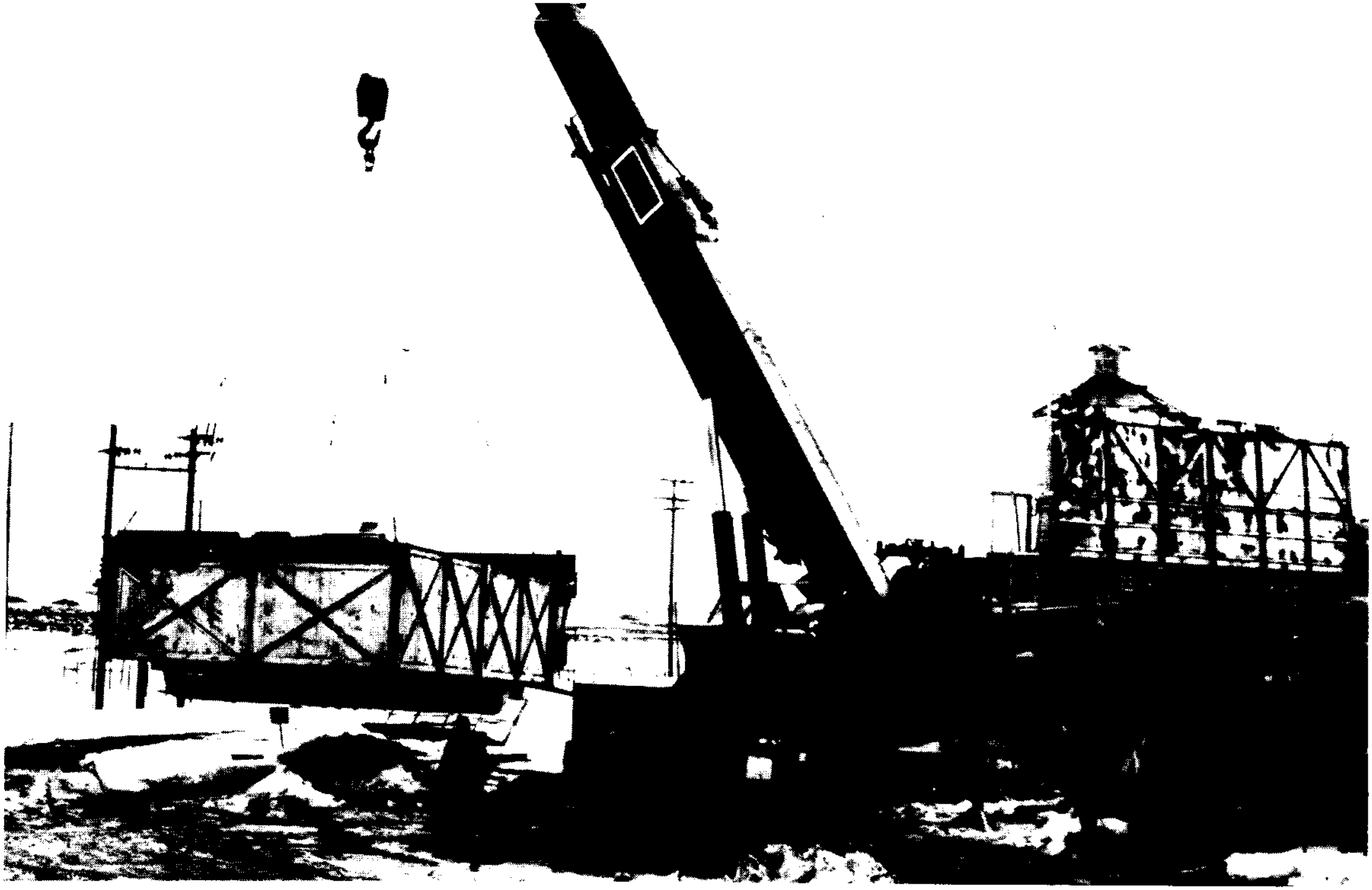


Figure 38. Removal of the air blast heat exchanger uncontaminated structure.

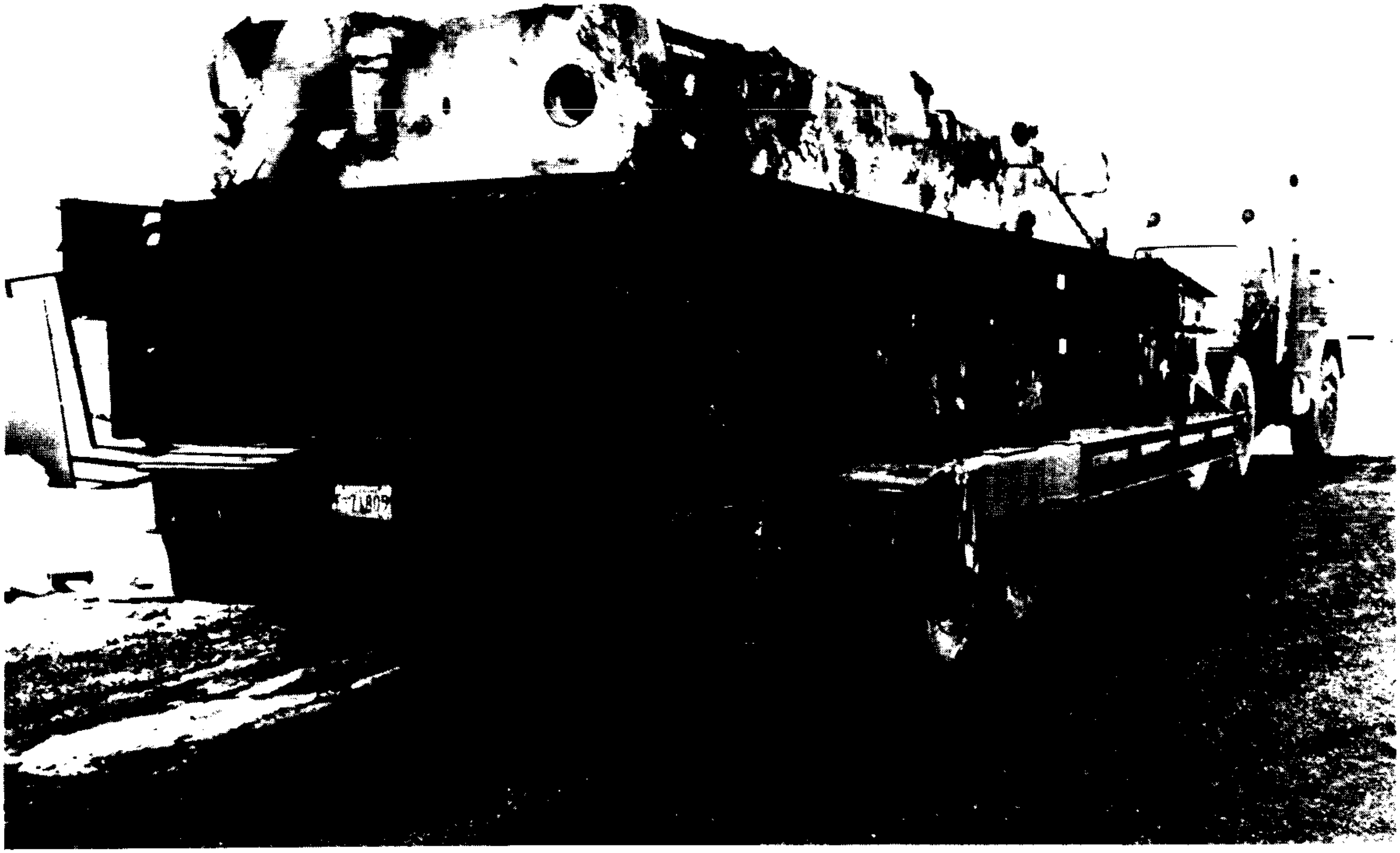


Figure 39. IRL heat exchanger loaded on top of air blast heat exchanger tube sheets.

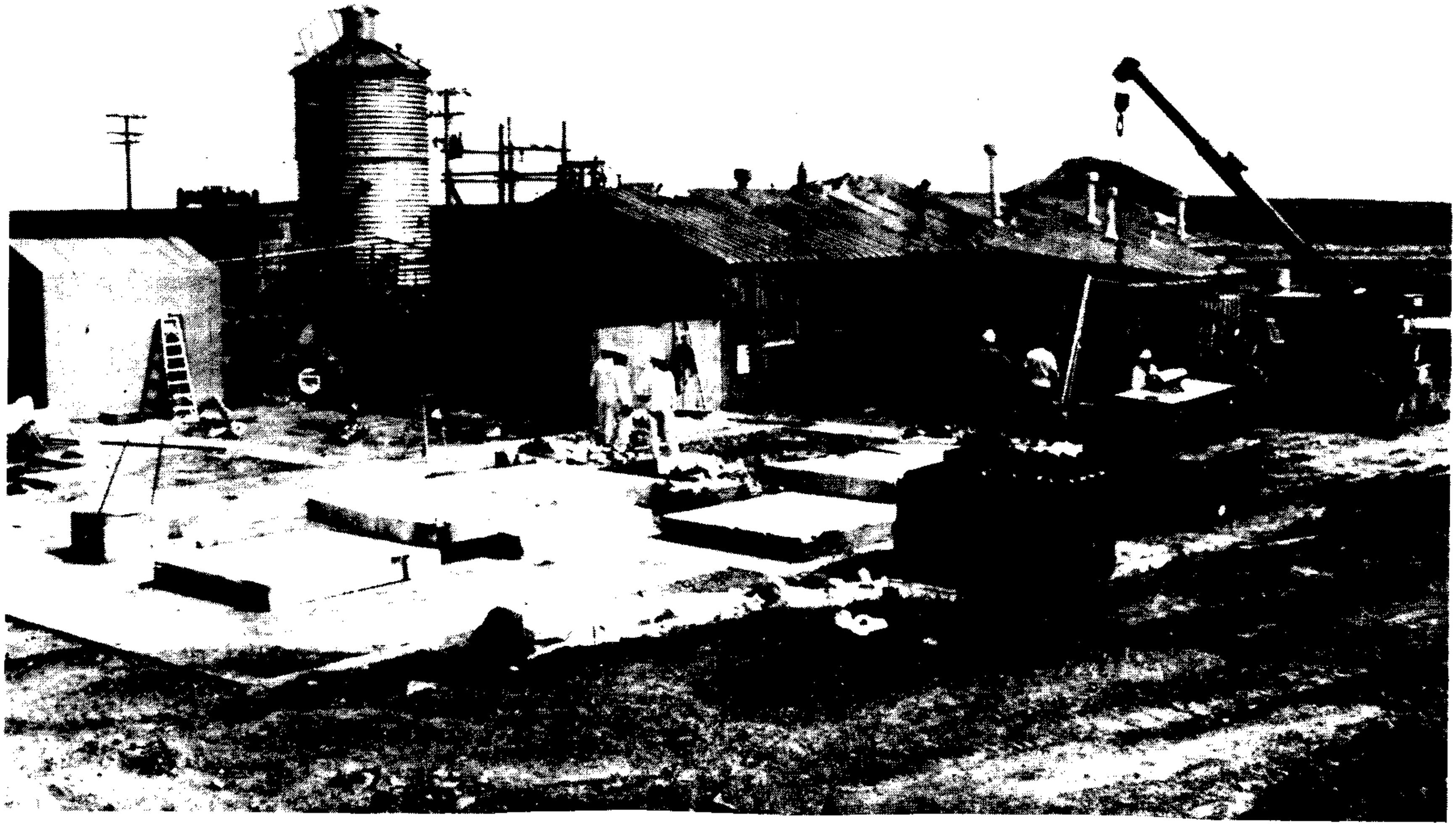


Figure 40. West side of process and control building after removal of air blast heat exchanger and the IRL system.

Figure 41. Starting disassembly of the process and control building.

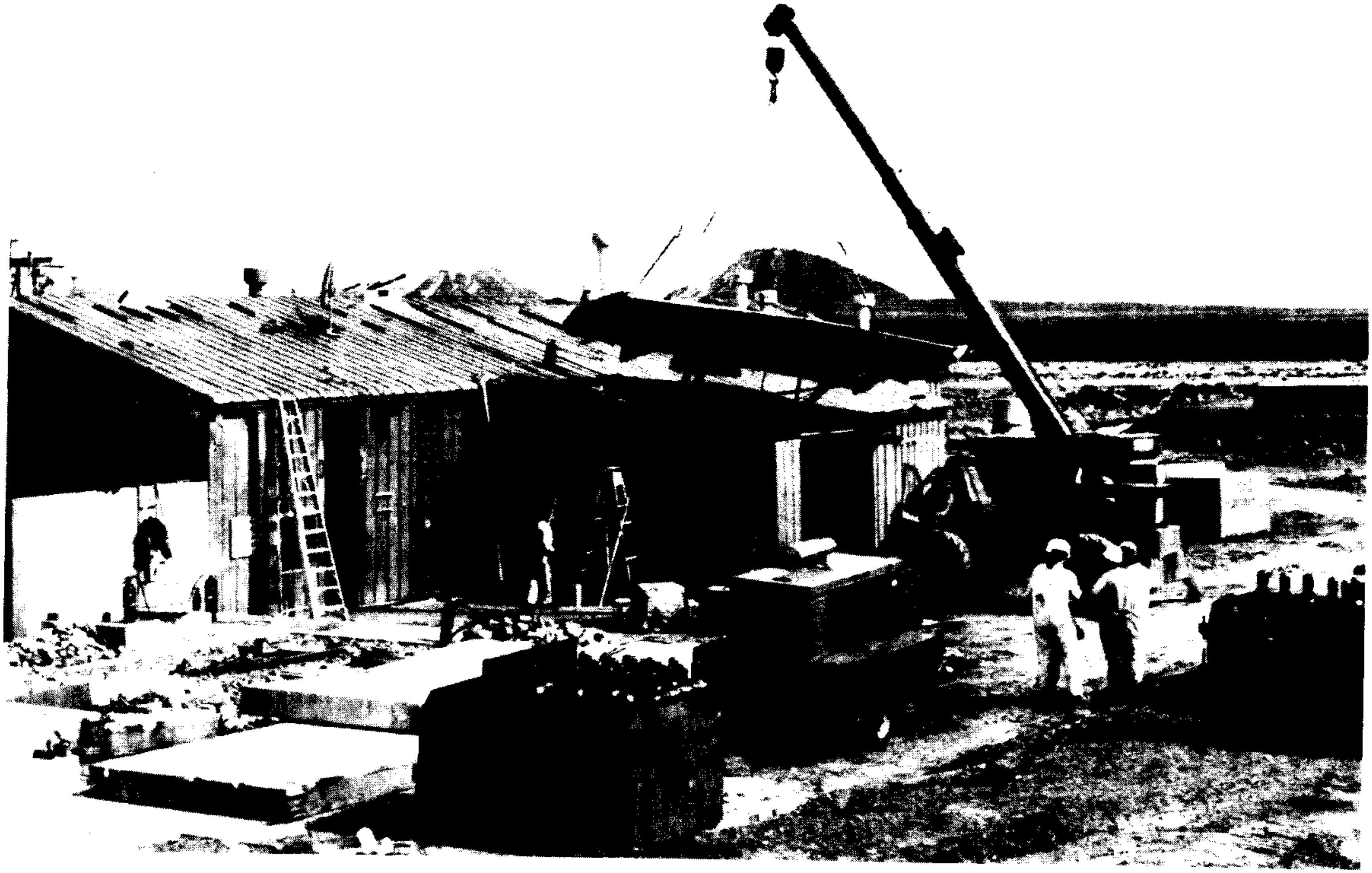


Figure 42. Removing part of the process and control building.

Figure 43. OMRE site after piping and aboveground tanks have been removed. Concrete demolition in progress.

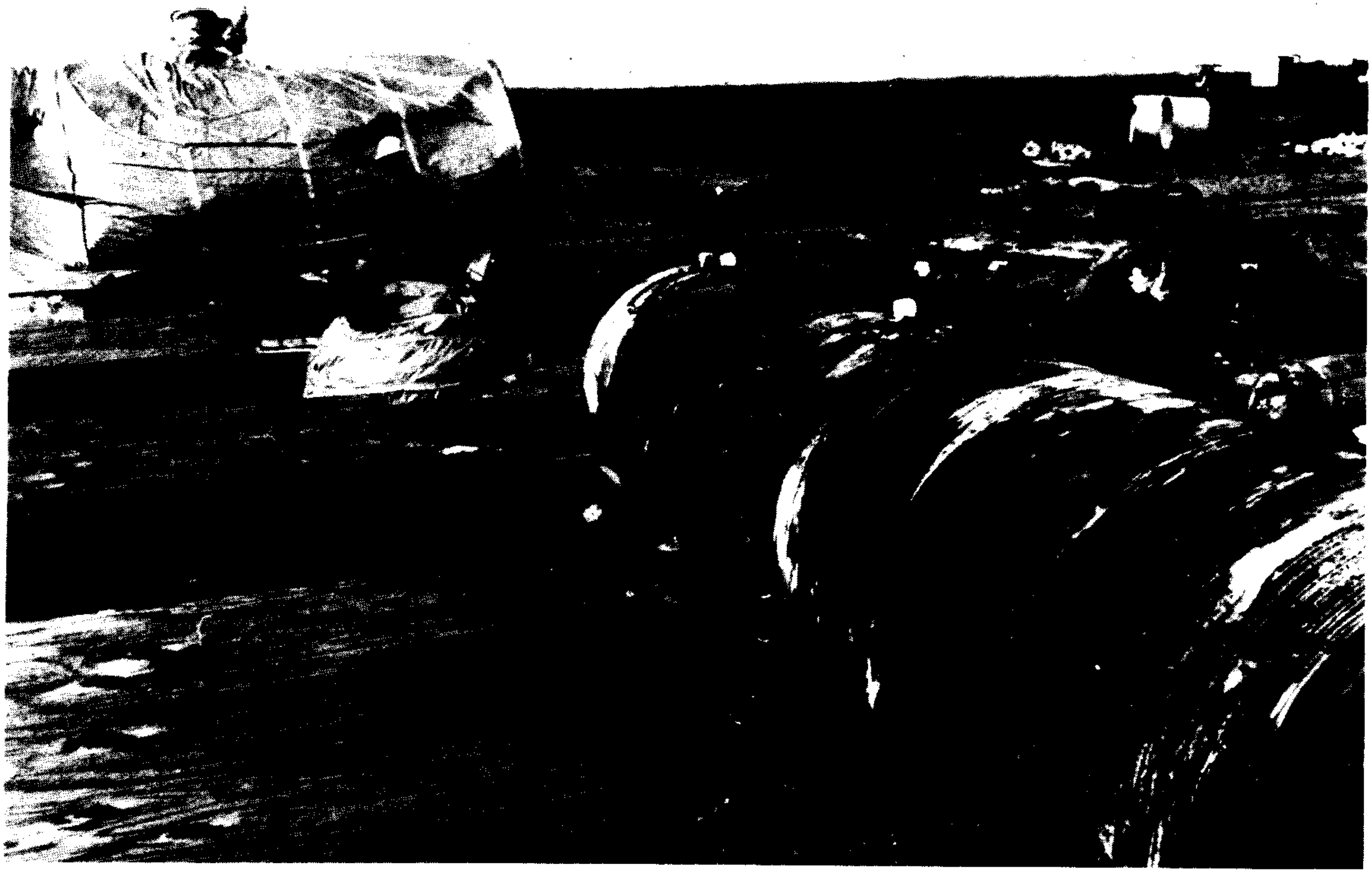


Figure 44. Contaminated tanks ready for shipment to RWMC.

Figure 45. Uncontaminated xylene storage tank.

Figure 46. Rigging to xylene storage tank.

Figure 47. Contaminated waste water tank excavated from under cordox system concrete slab.

Figure 48. Rigging to the liquid waste tank.

Figure 49. Initial lifting of the liquid waste tank.

Figure 50.   Removing liquid waste tank.

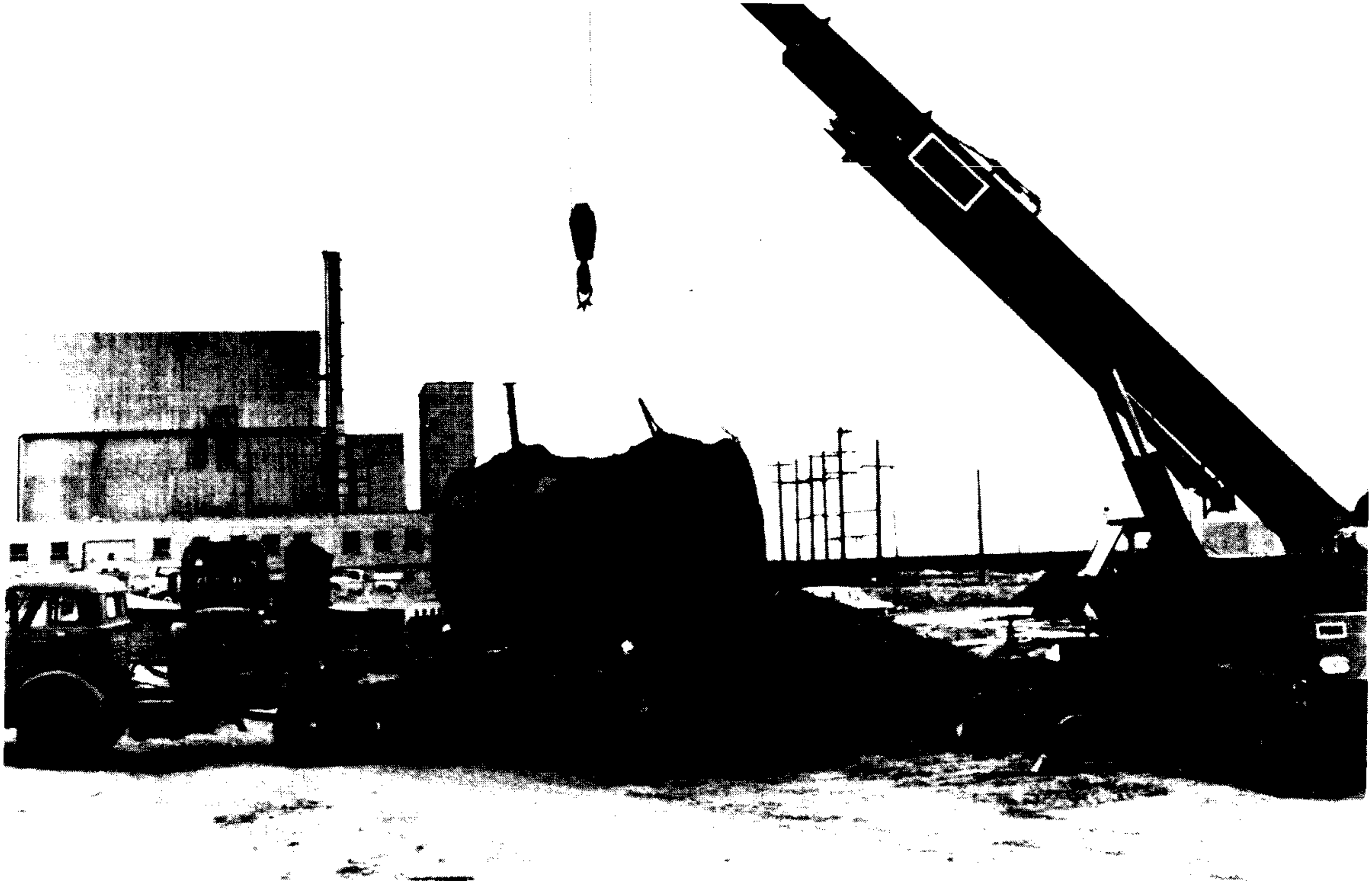


Figure 51. Setting liquid waste tank on lowboy.

Figure 52. Reactor drain tank vault. I-beams were cut and the drain tank hoisted from vault.

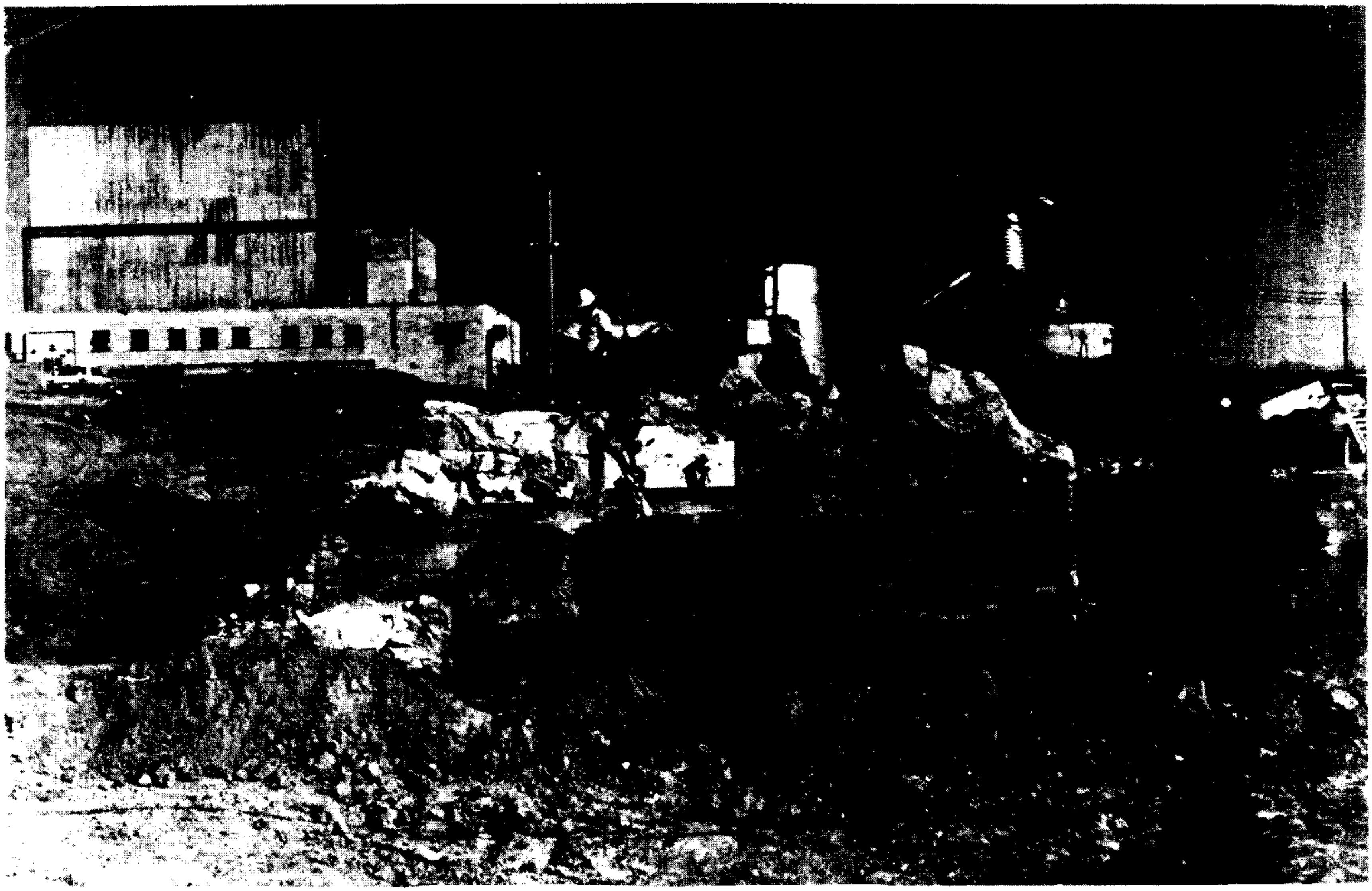


Figure 53. A portion of the shield wall broken with a "headache" ball. The drain tank vault is on the right and the reactor vessel is in the background. Tank and building in the background are parts of EOCR.

Figure 54. Burying parts of the uncontaminated shield wall.

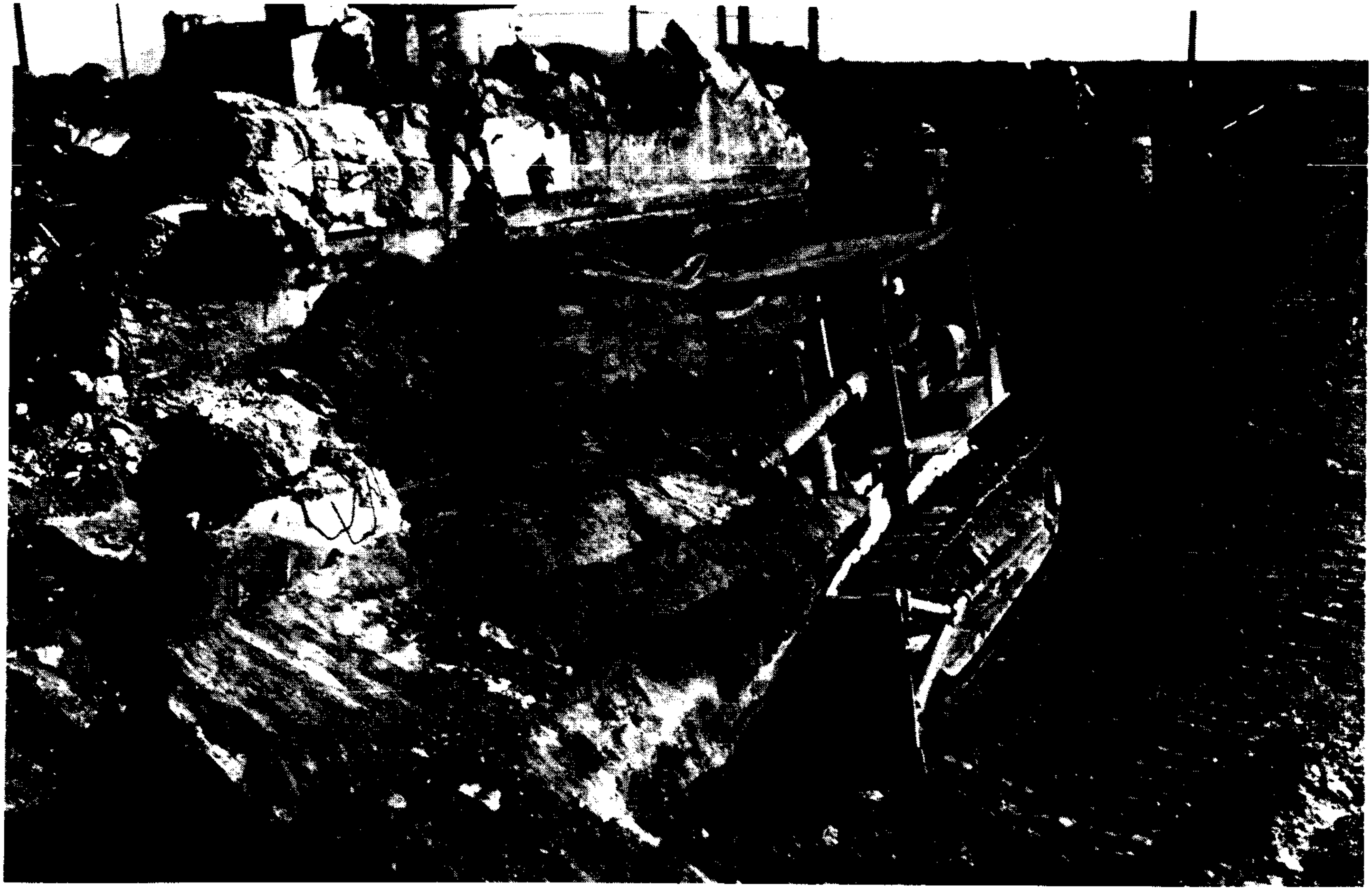


Figure 55. Concrete demolition in progress.

Figure 56. Moving uncontaminated concrete for burial.

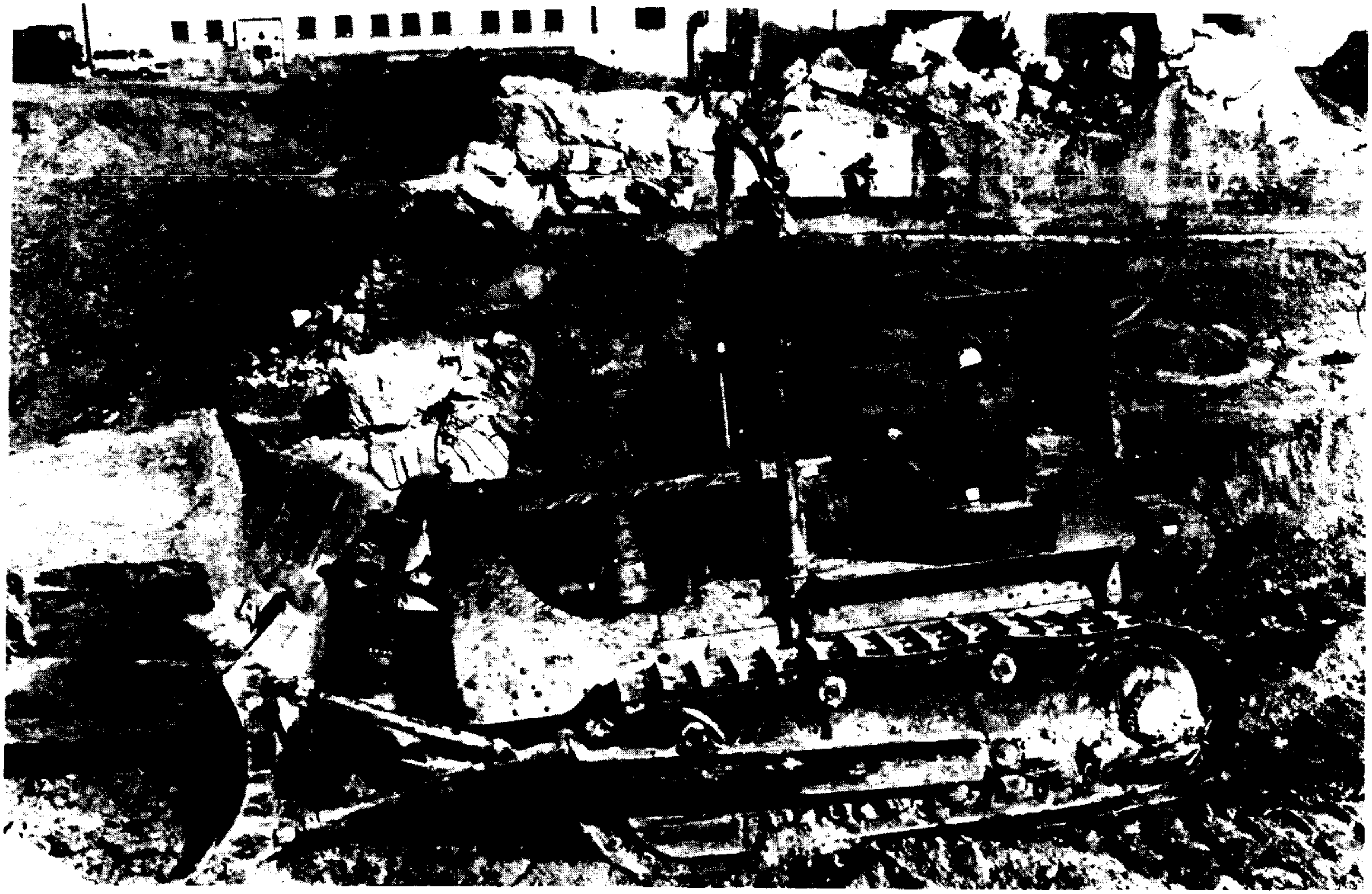


Figure 57. Digging a pit at the foot of the shield wall.

Figure 58. Excavating soil from the pipe gallery silo.

Figure 59. Exposed pipe gallery silo concrete cover slab removed.

Figure 60. Clamshell shovel digging contaminated soil.

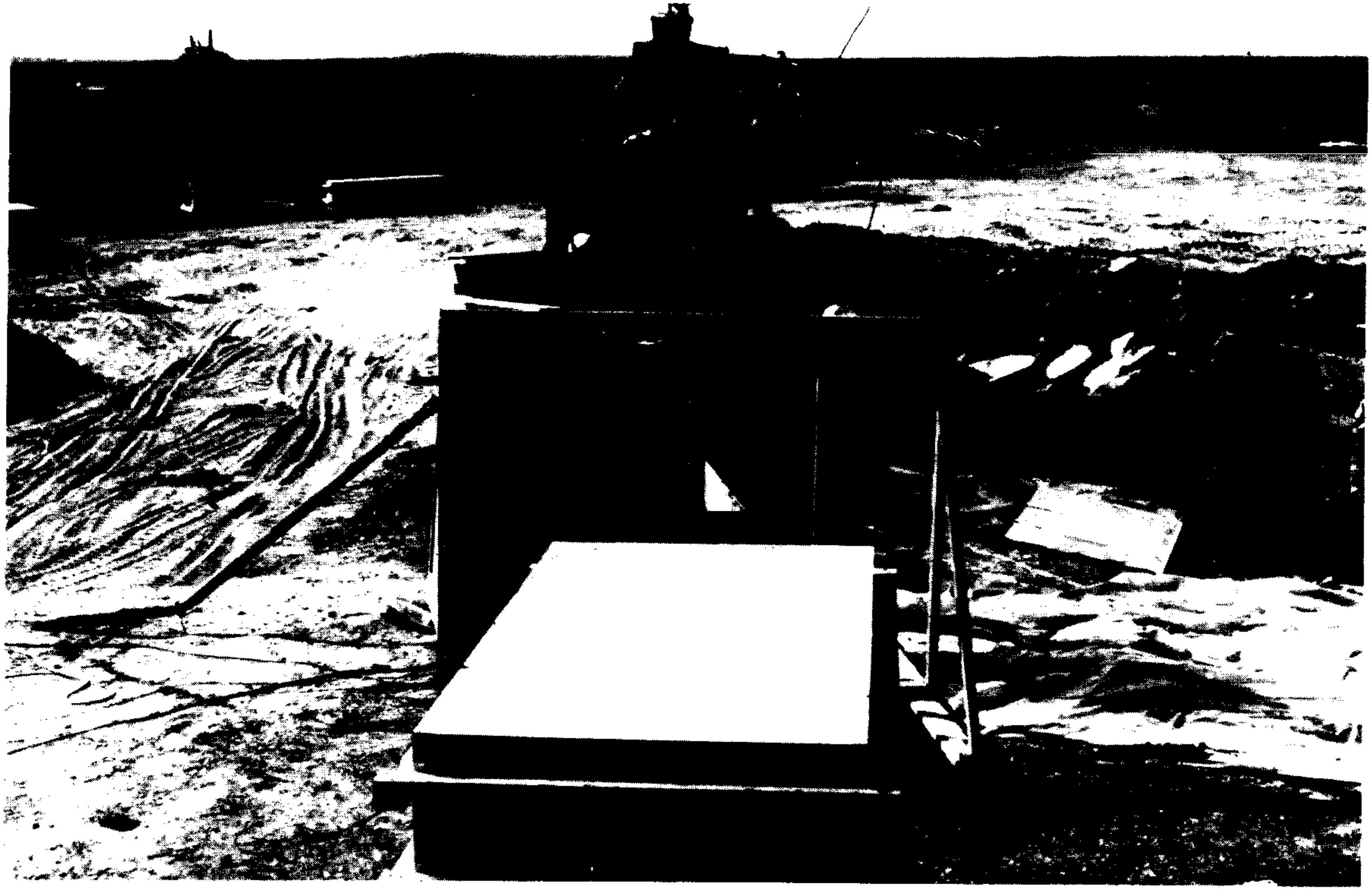


Figure 61. Clamshell shovel loading contaminated soil in 2 x 4 x 8 ft box. Note plastic sheet on ground.

Figure 62. Reactor and pipe gallery foundations during construction – July 1956. Reactor foundation in back.

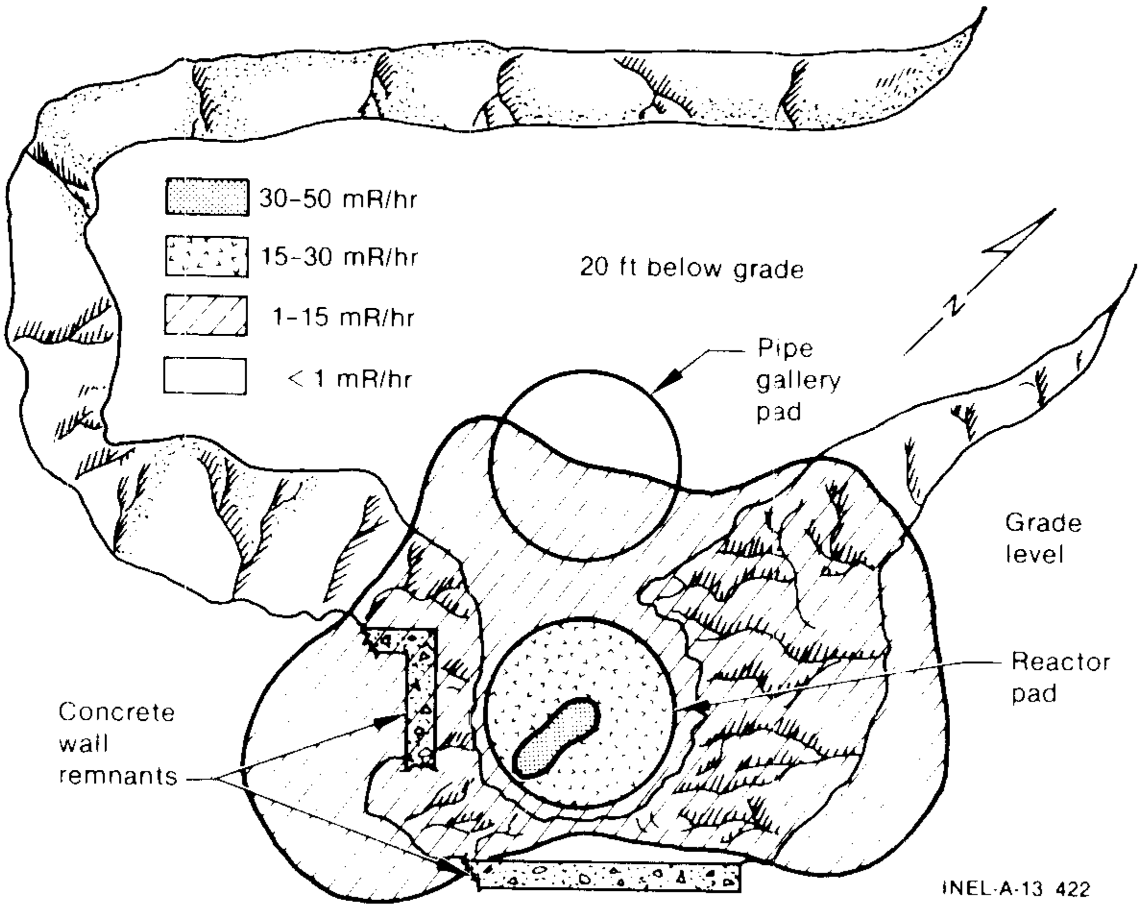


Figure 63. Radiation map of OMRE excavation.

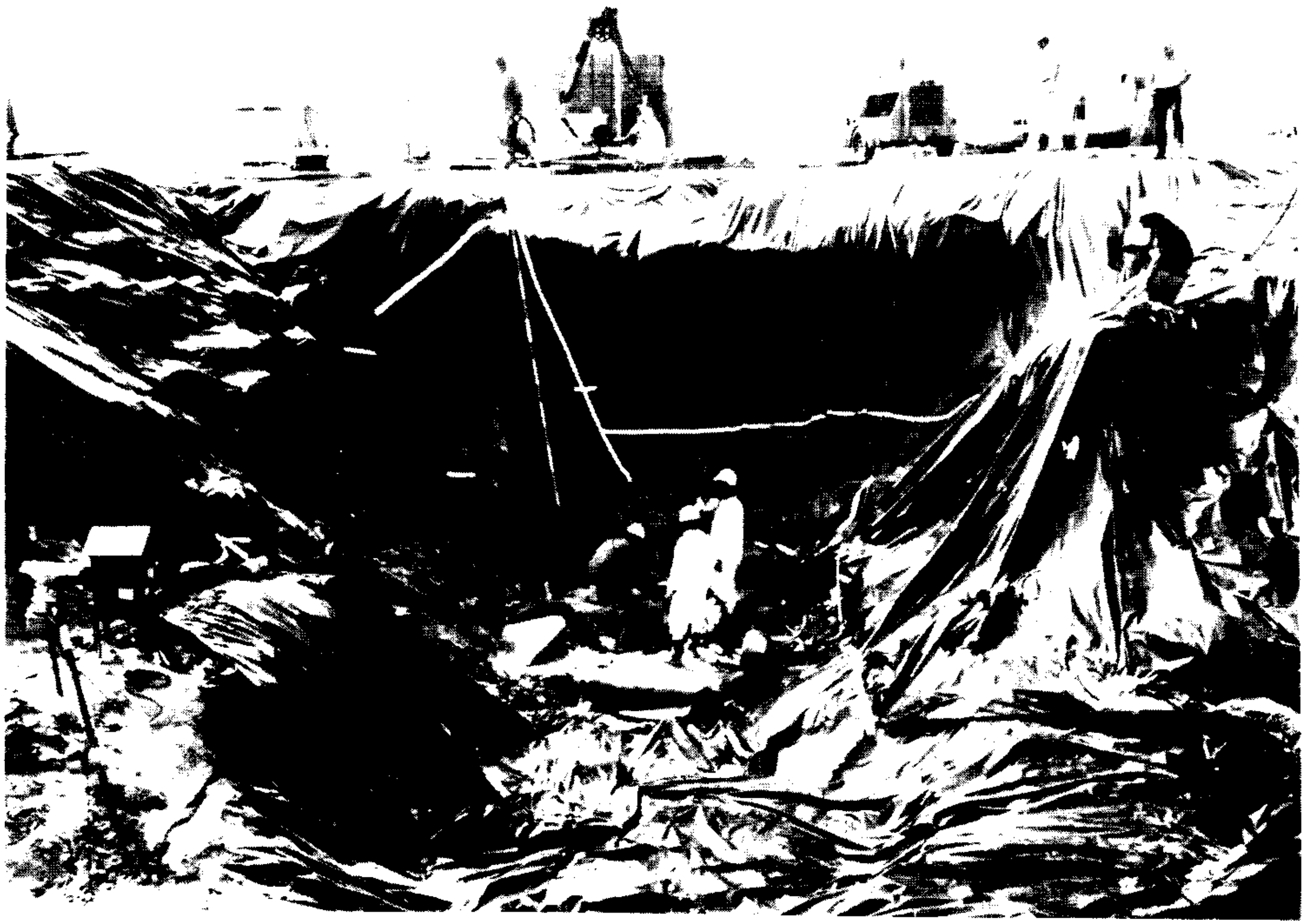


Figure 64. Preparing the excavation for blasting.

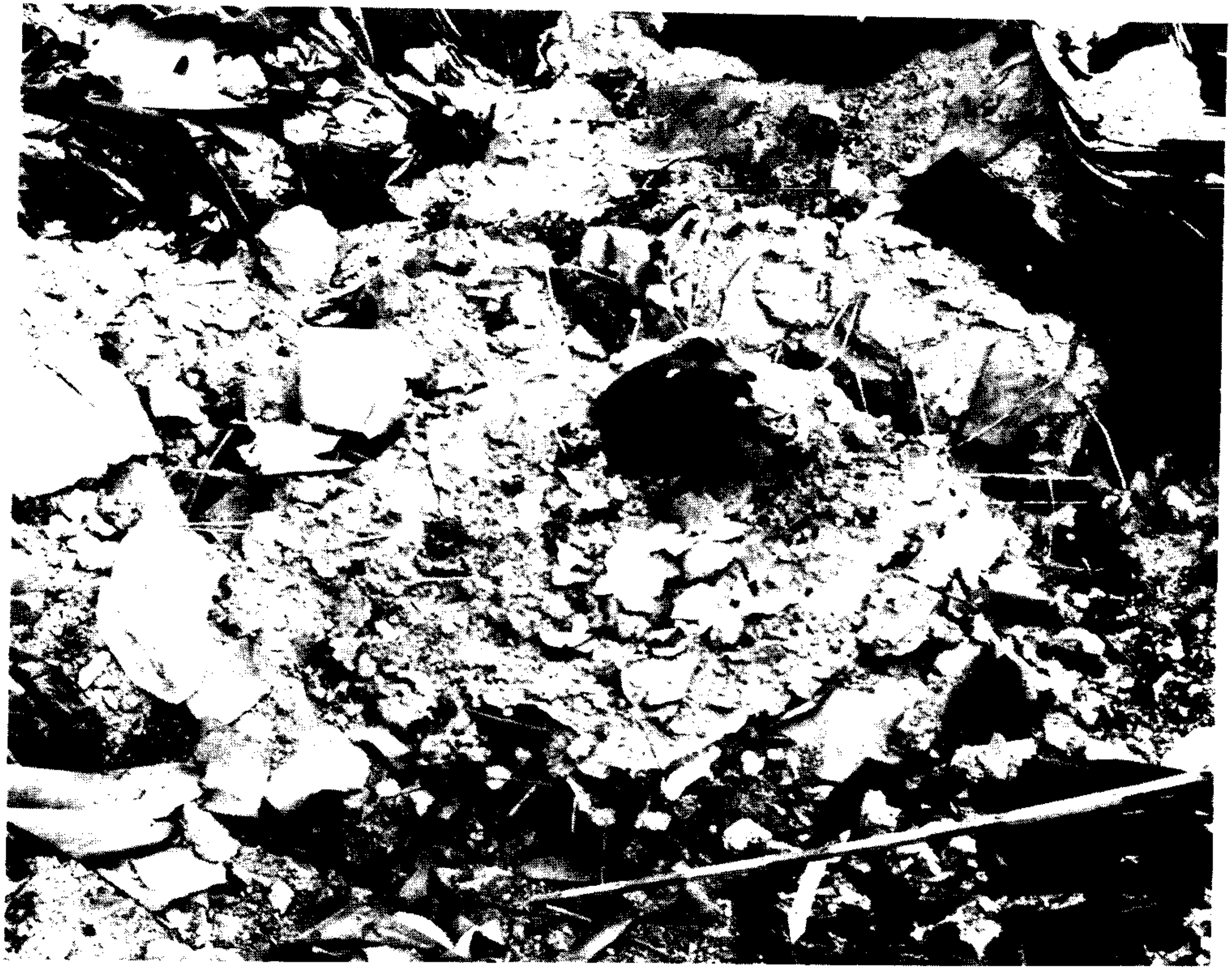


Figure 65. Reactor pad after blasting.

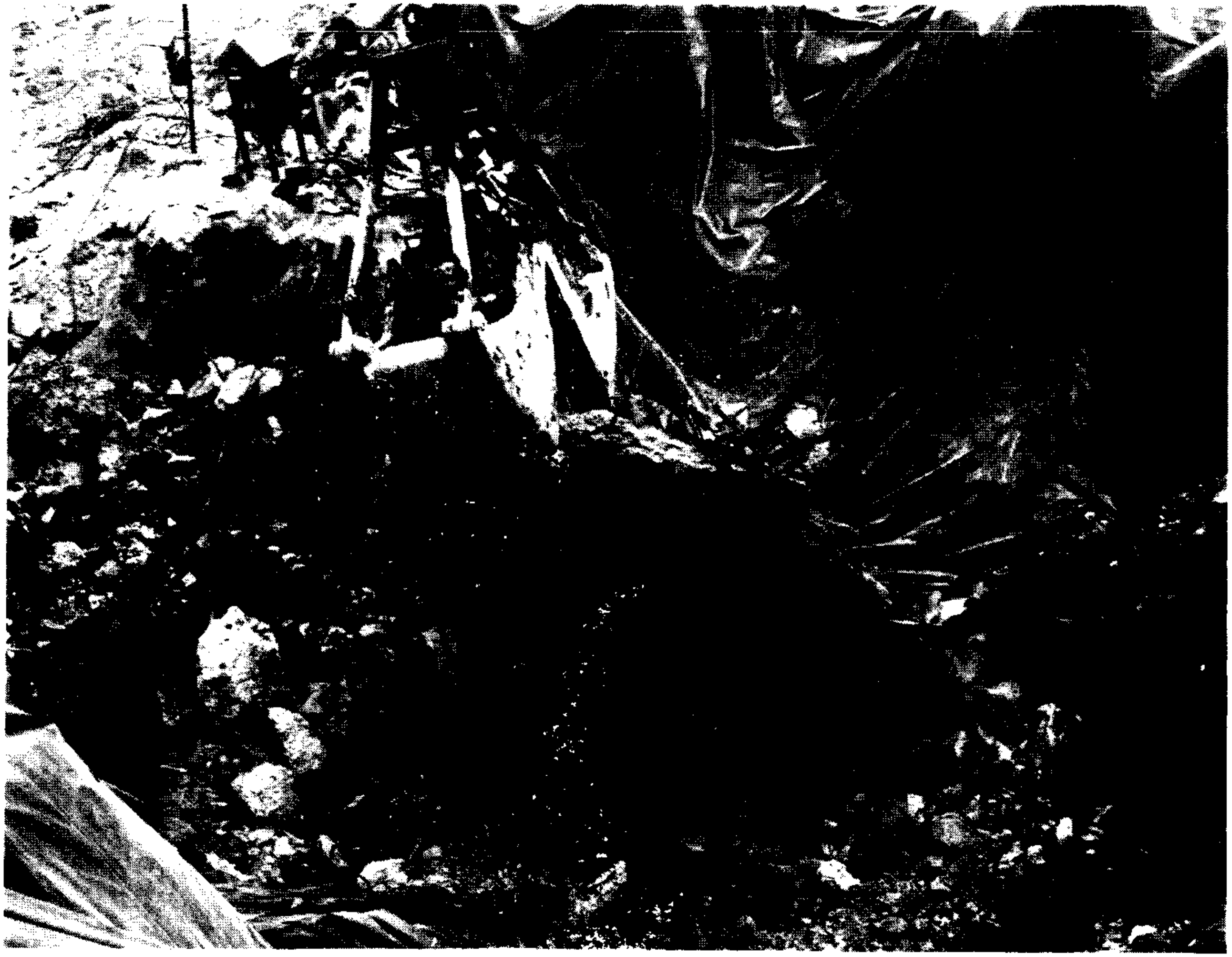


Figure 66. Remnant of reactor pad loose from basalt.

Figure 67. Setting charges in excavation basalt.

Figure 68. Basalt rubble after blasting.

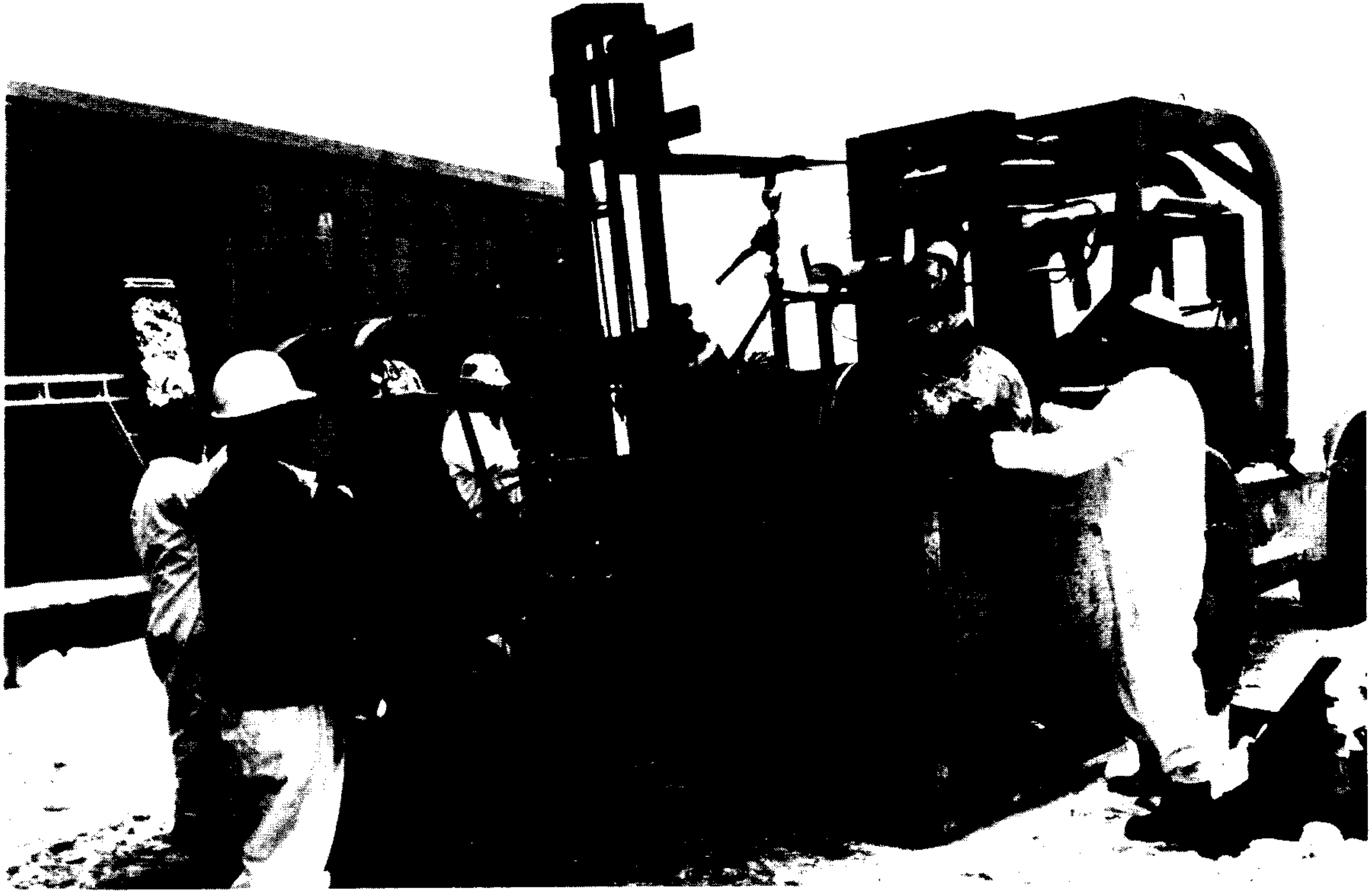


Figure 69. Contaminated tank placed in plywood box.

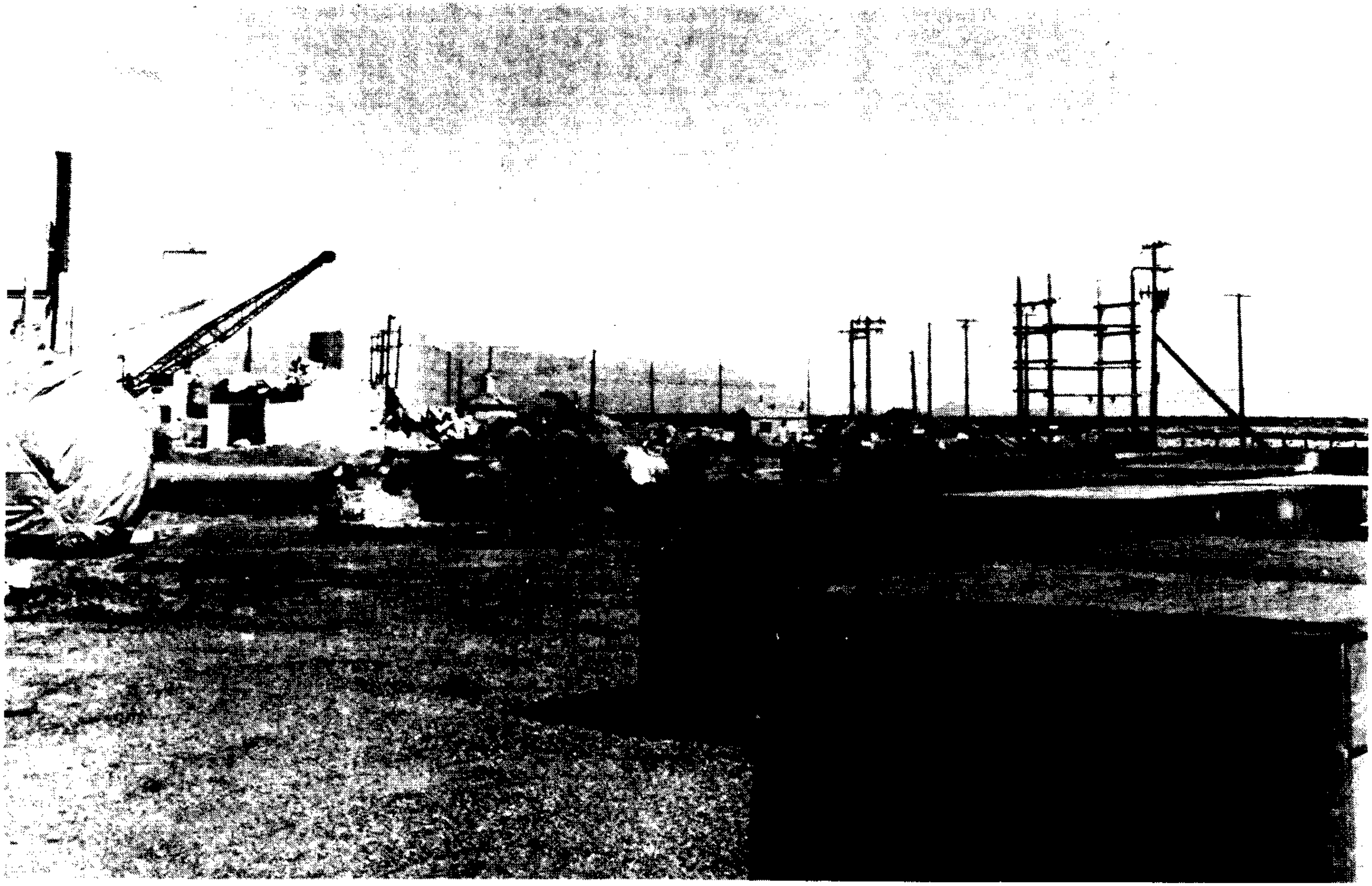


Figure 70. Staging area for contaminated waste.

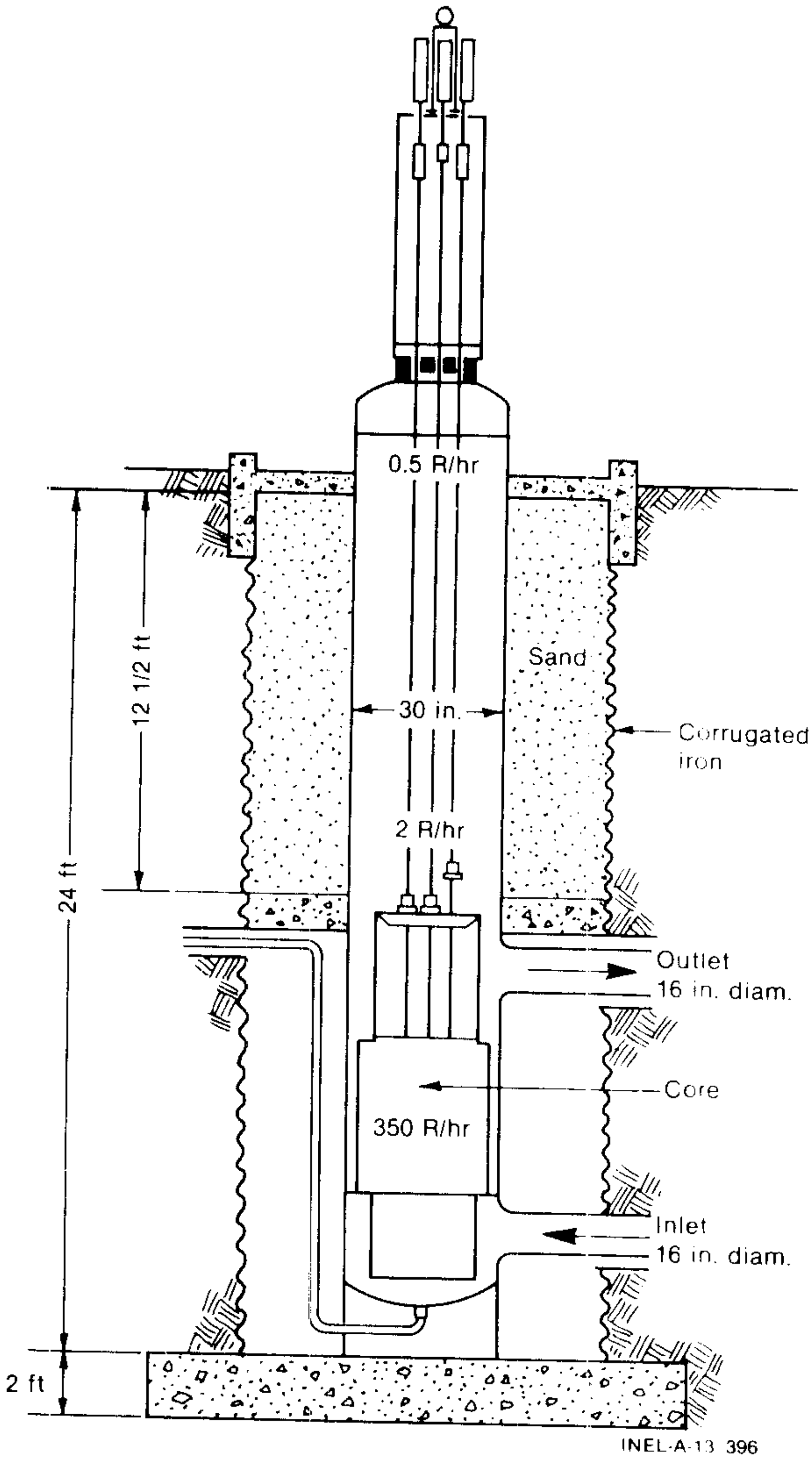


Figure 71. Reactor vessel installation.

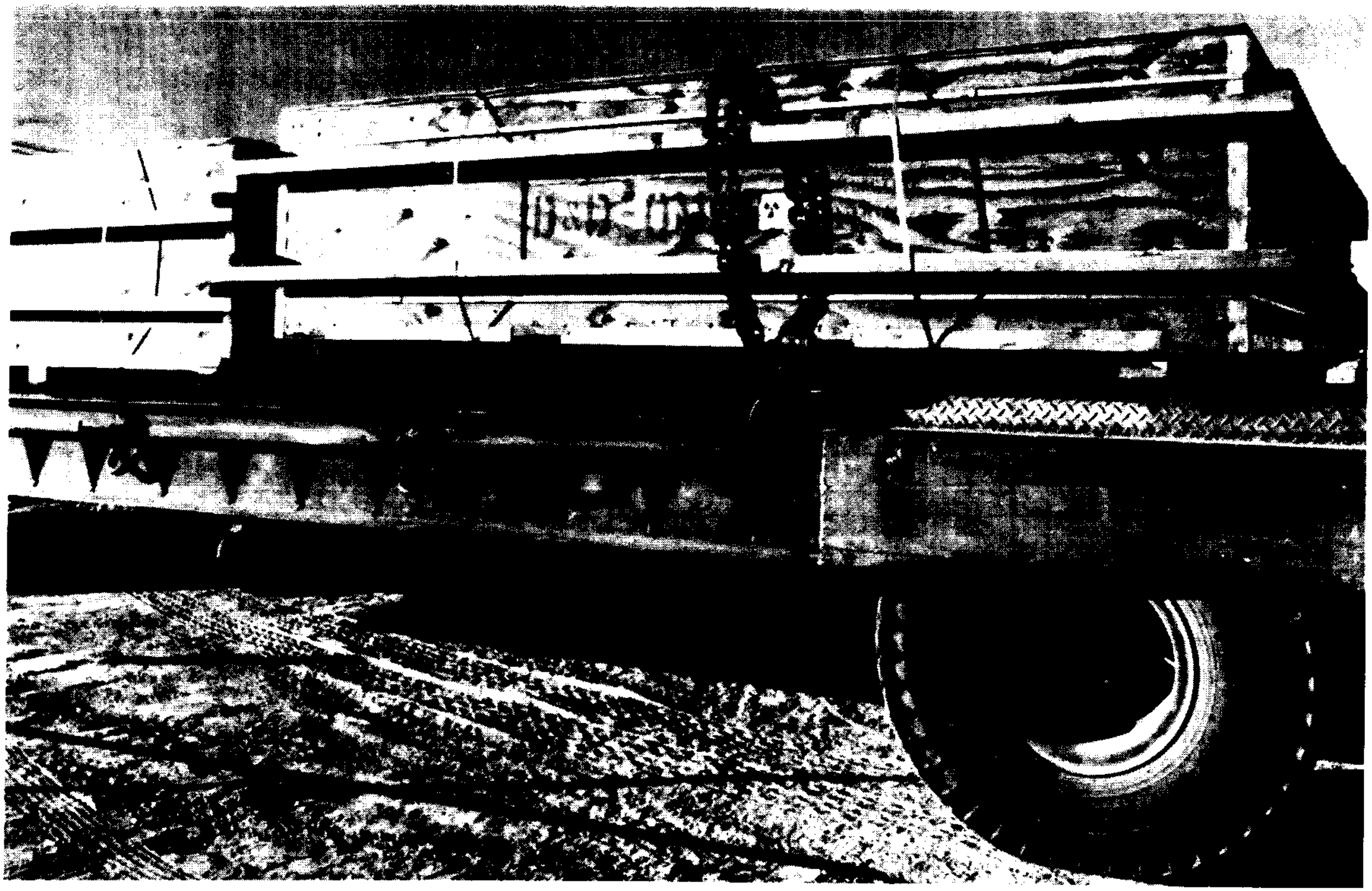


Figure 72. Improper loading of soil box.

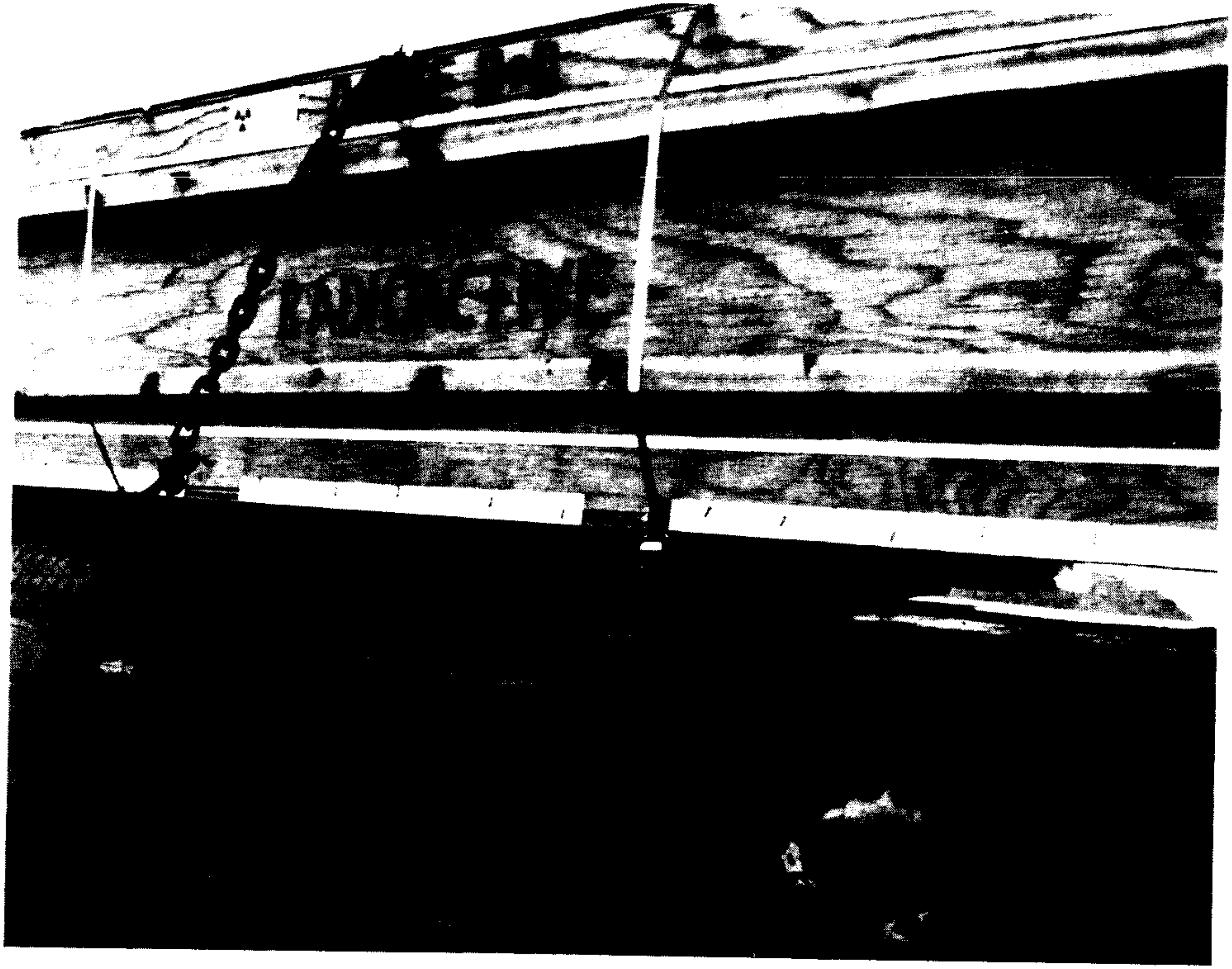


Figure 73. Soil box skids separating because support was inadequate.

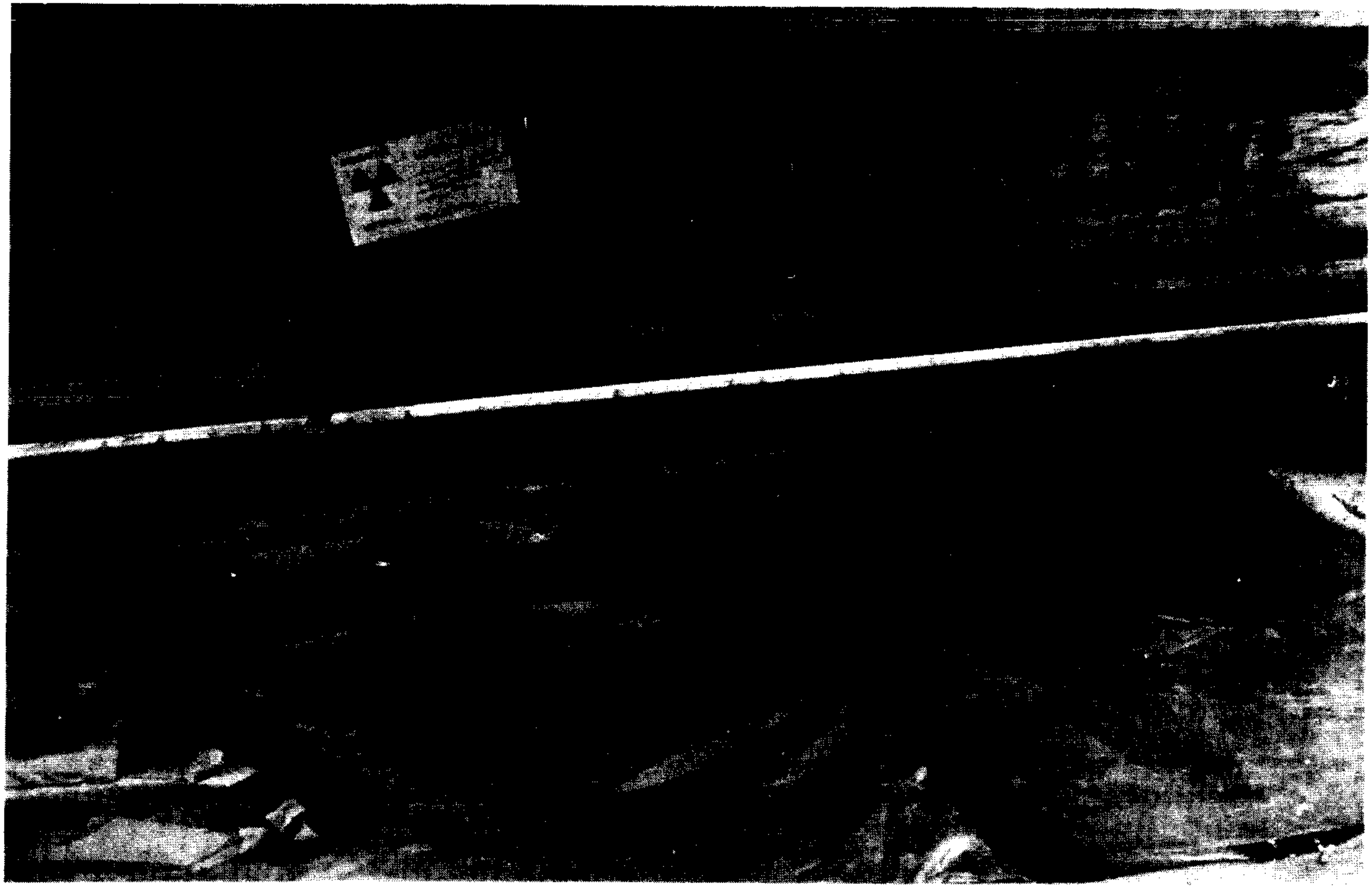


Figure 74. Ruptured bottom seam of soil box.

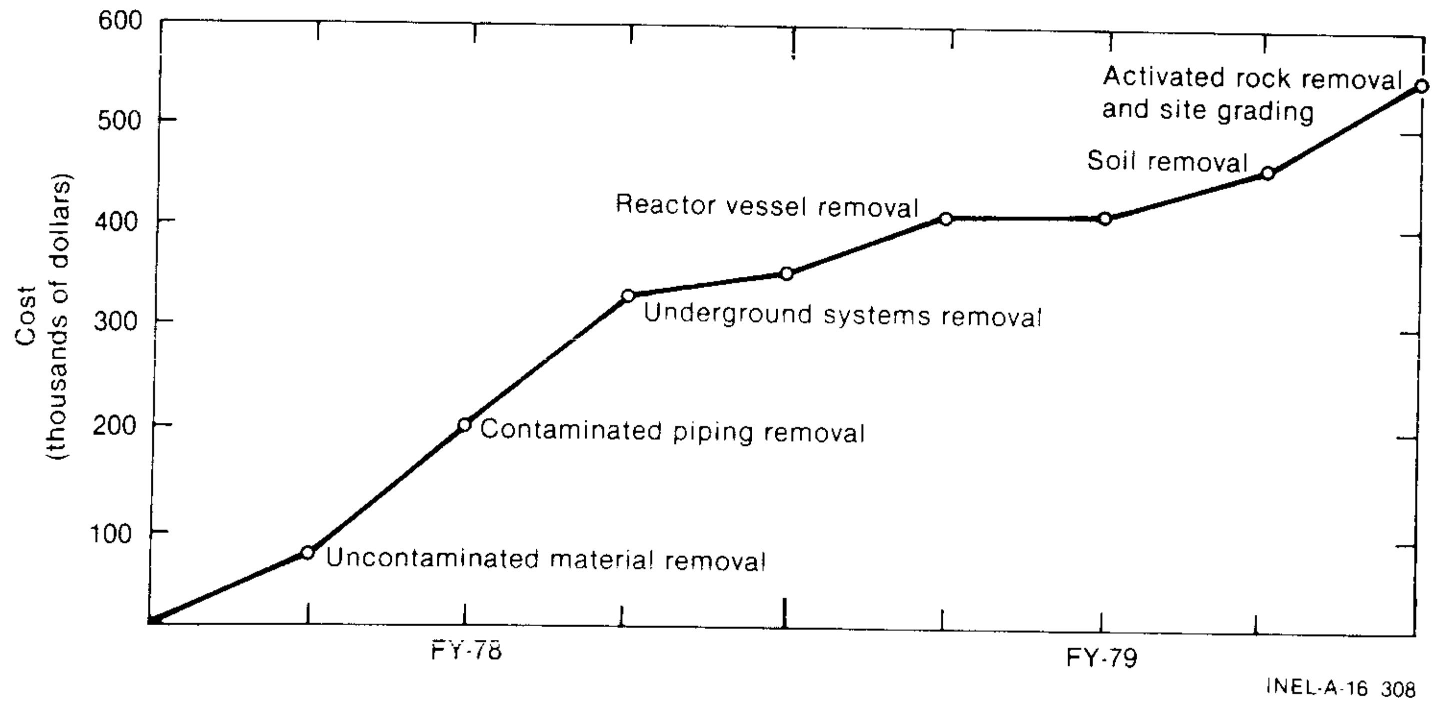


Figure 75. OMRE D&D cost history

REFERENCES

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2.[a] *EG&G Safety Manual*, Section 5040.

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